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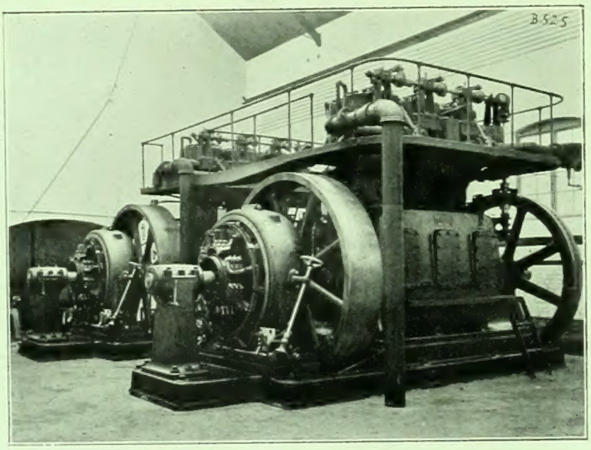

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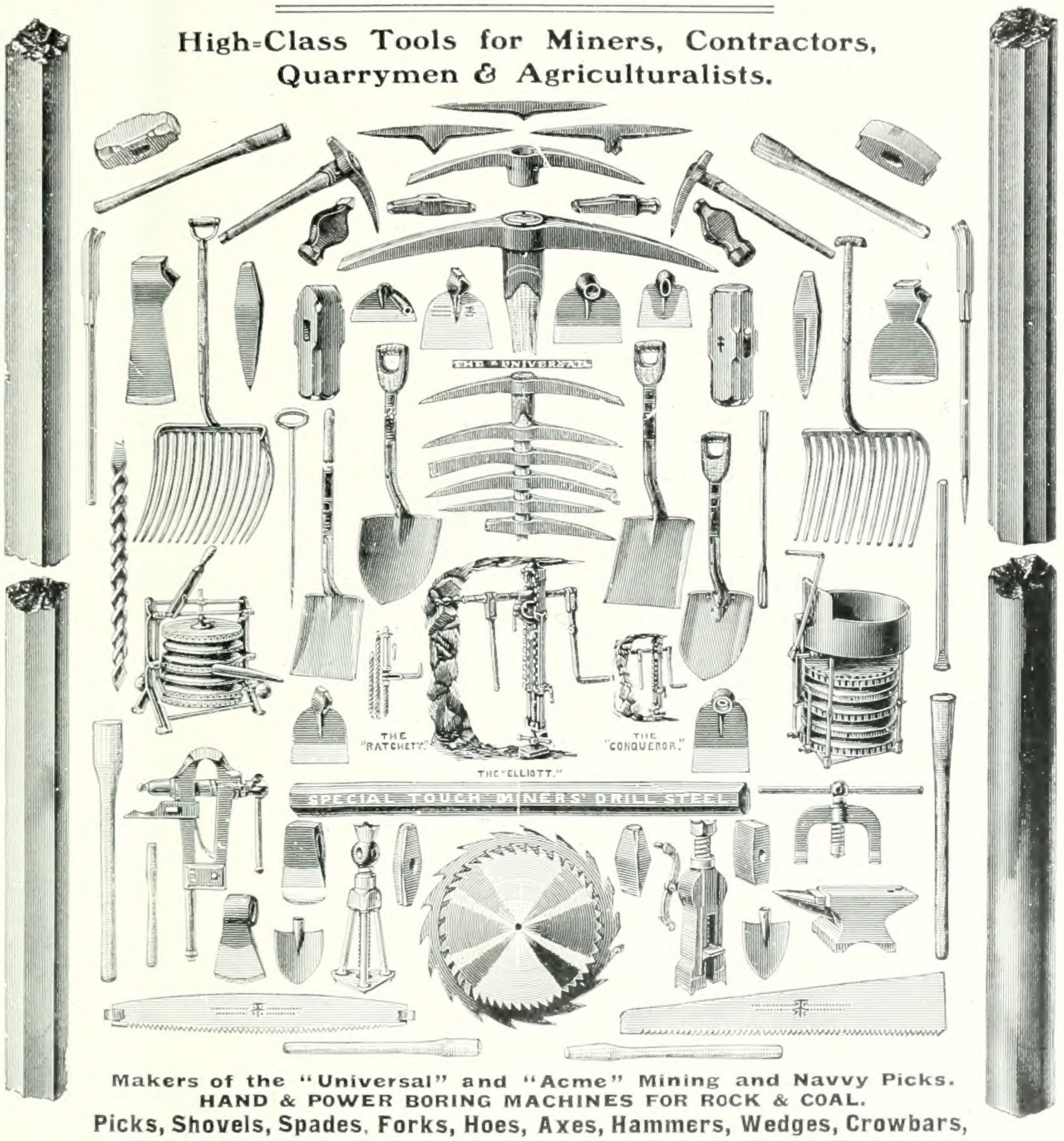
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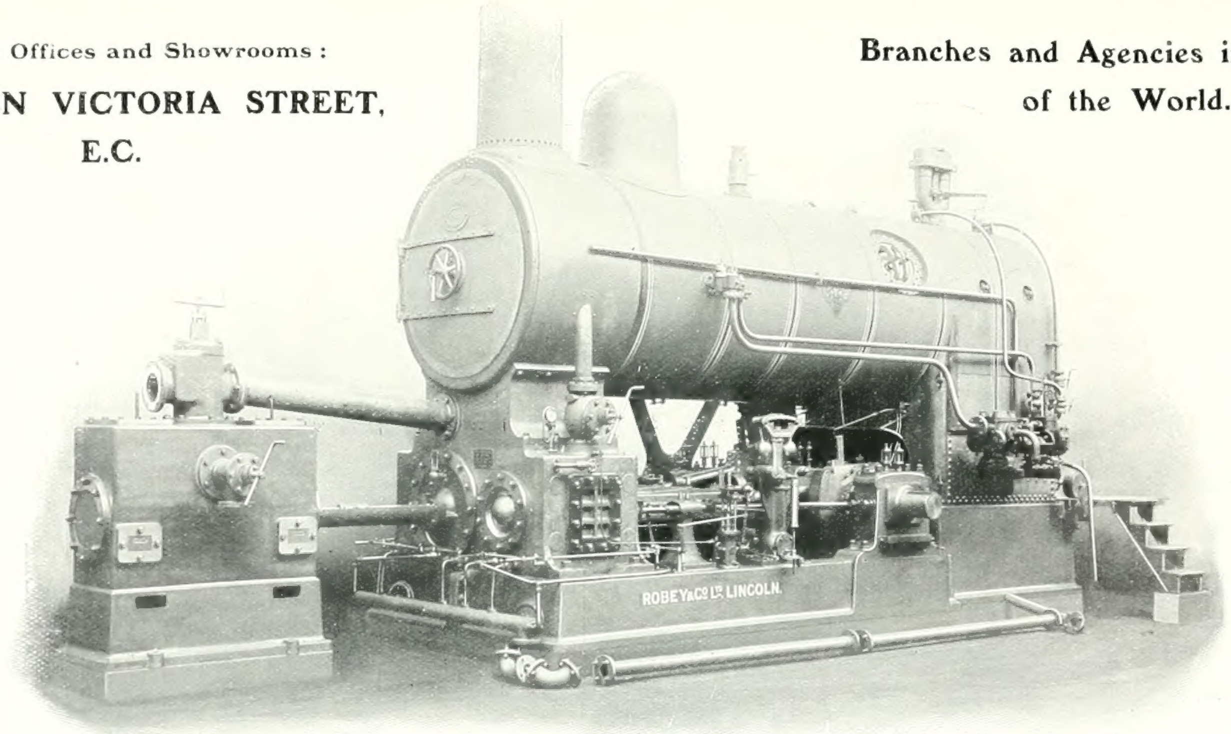

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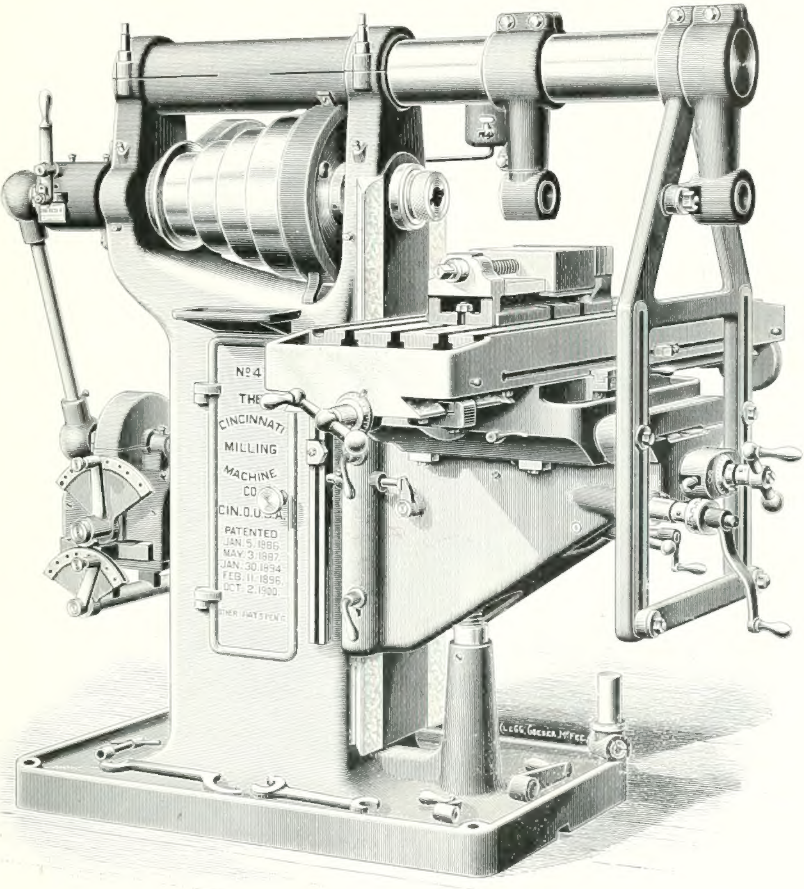

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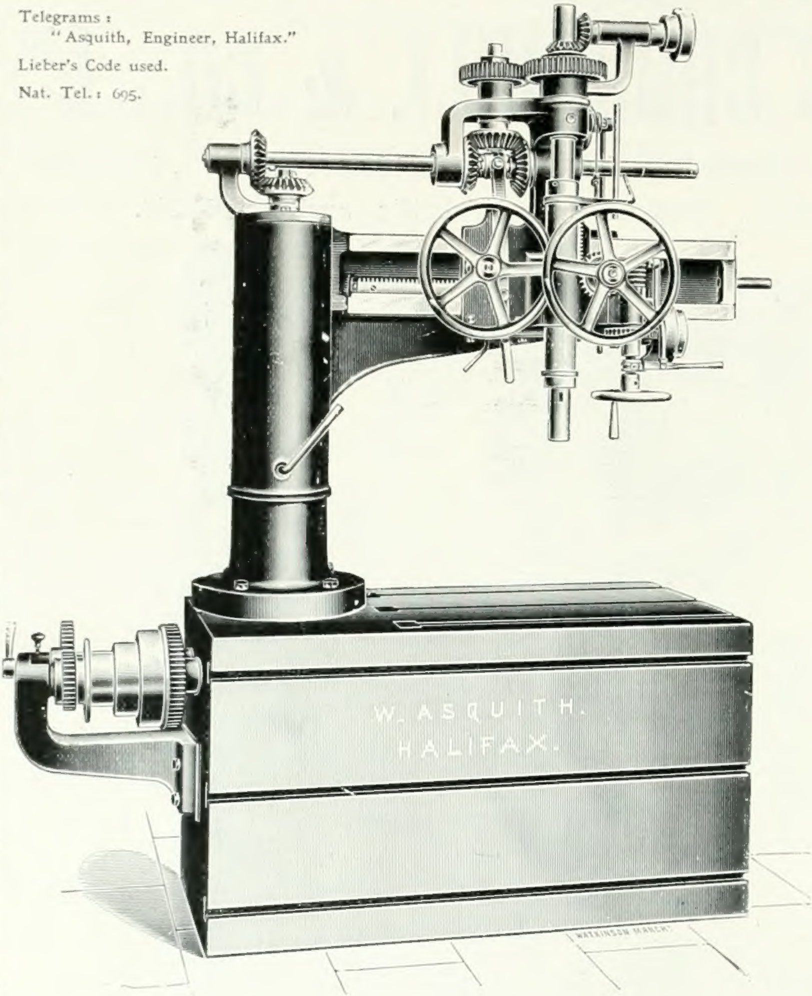

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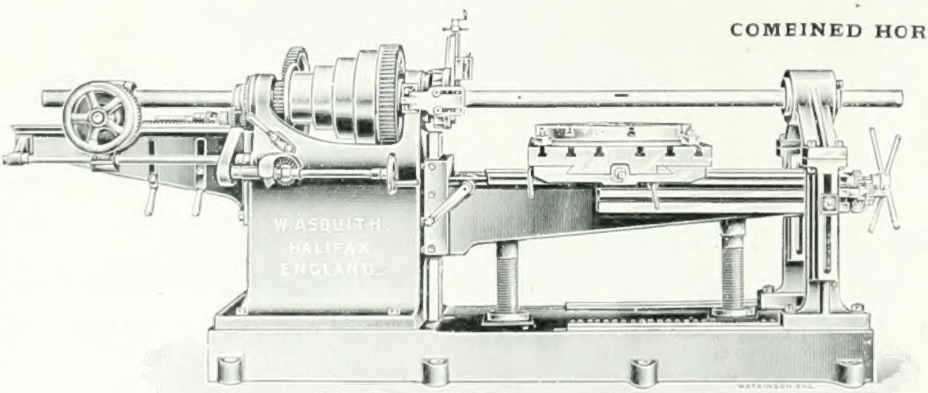

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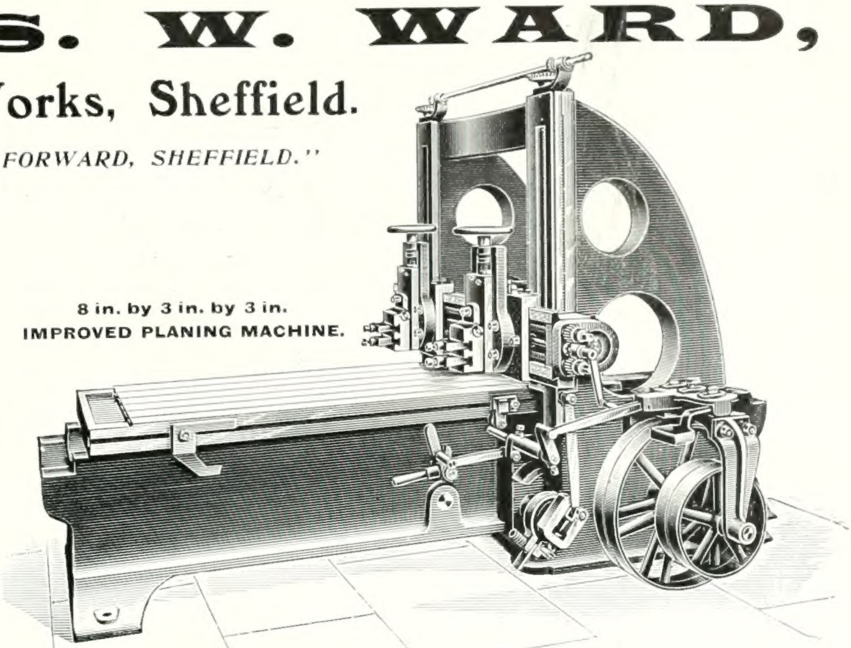

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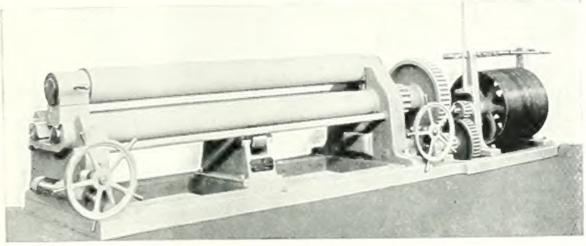

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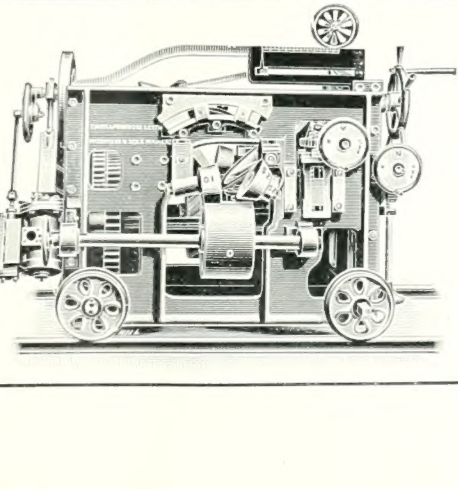

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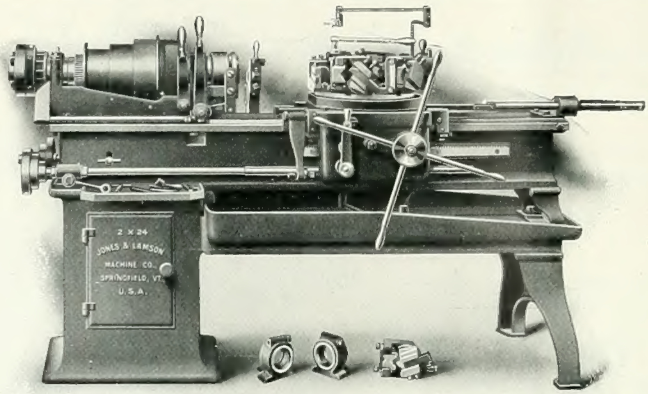

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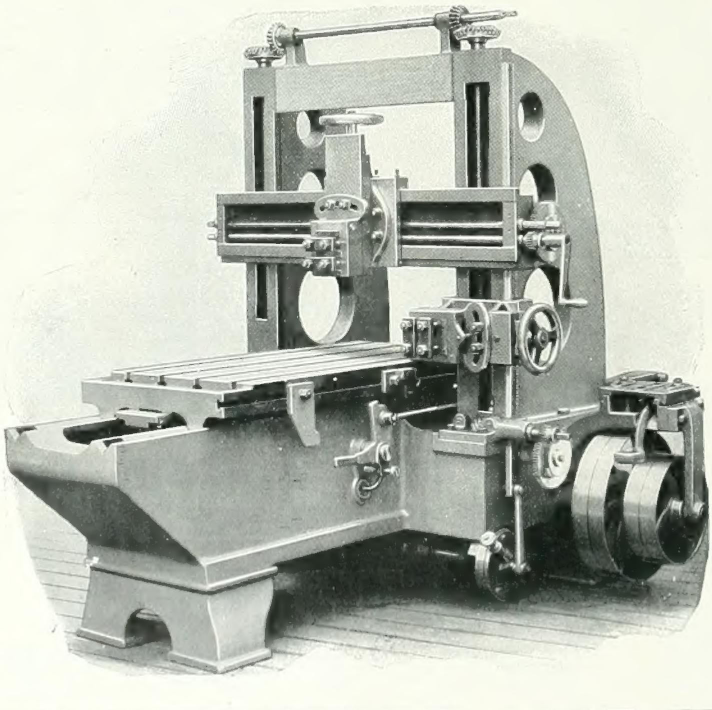

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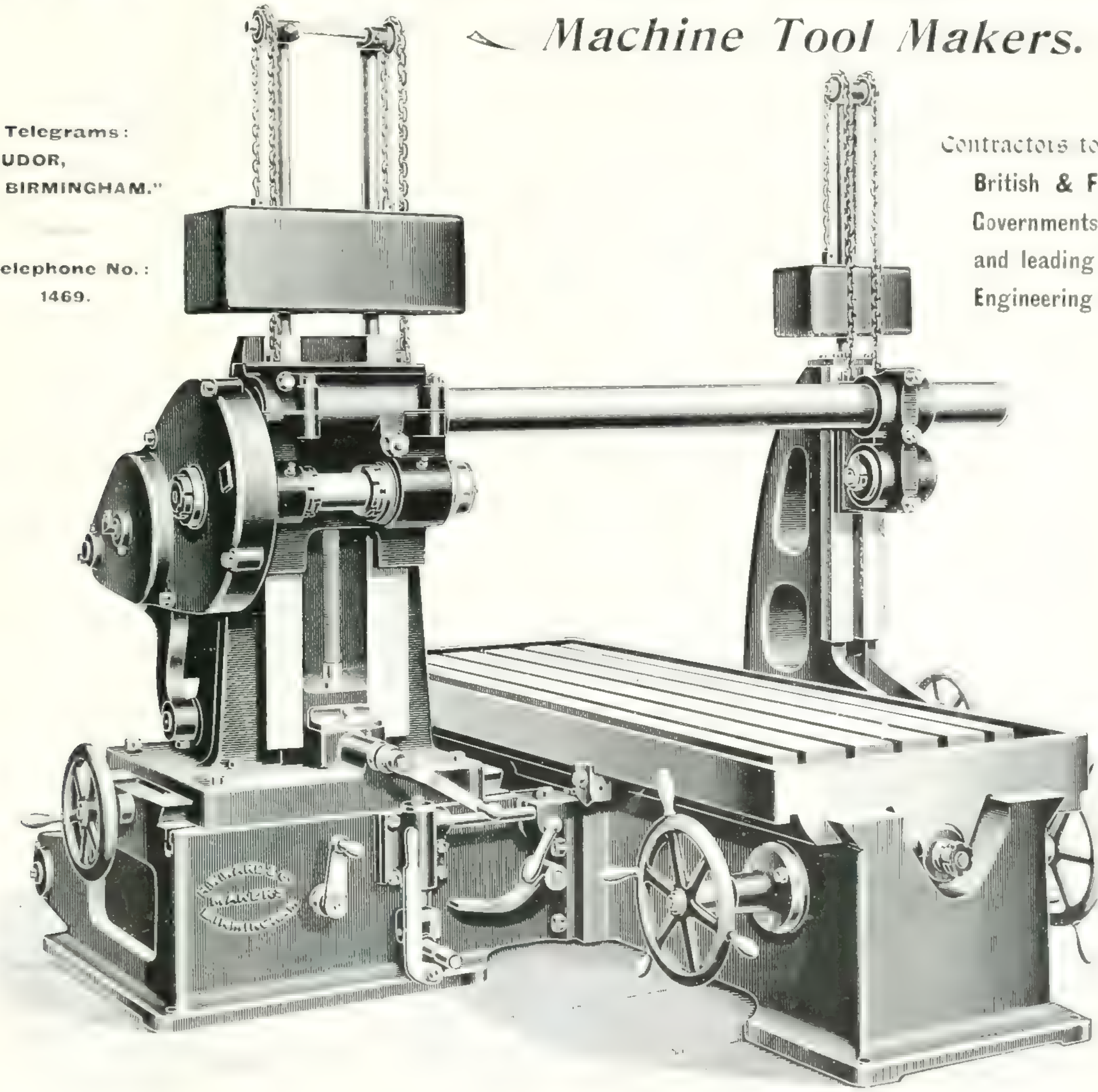

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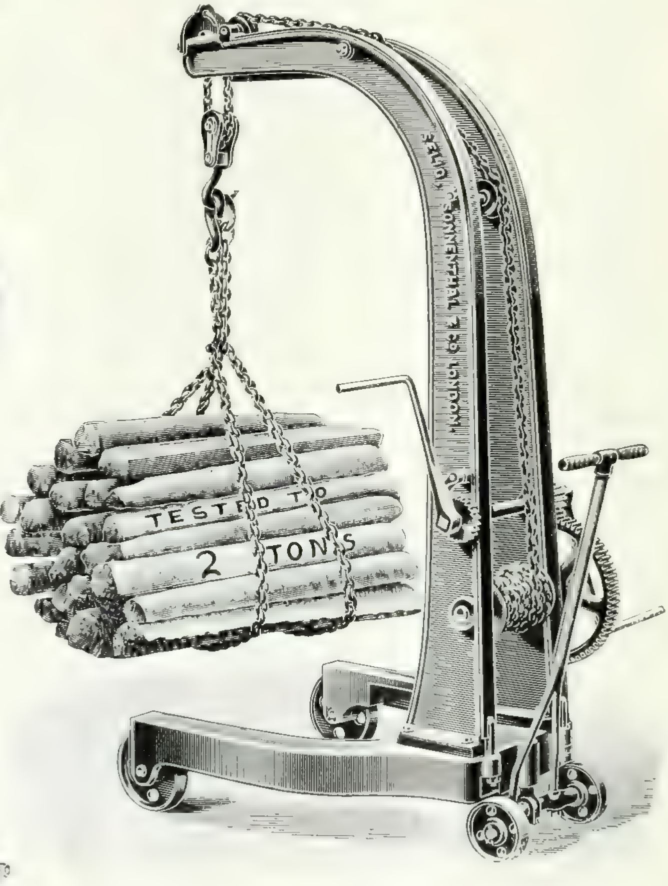

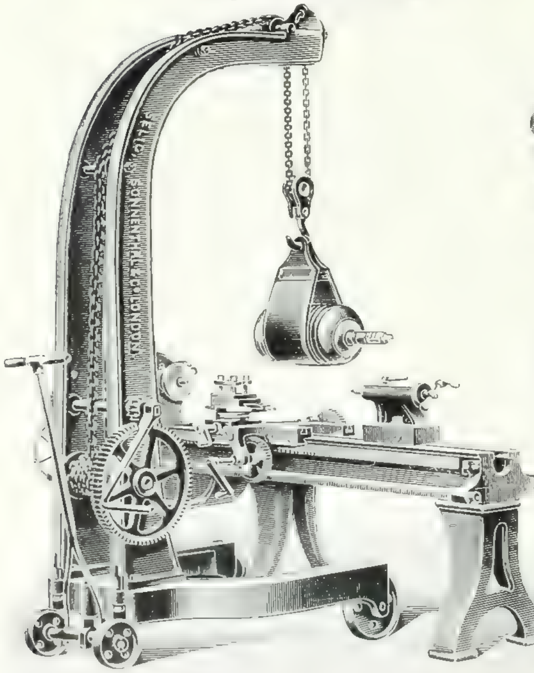

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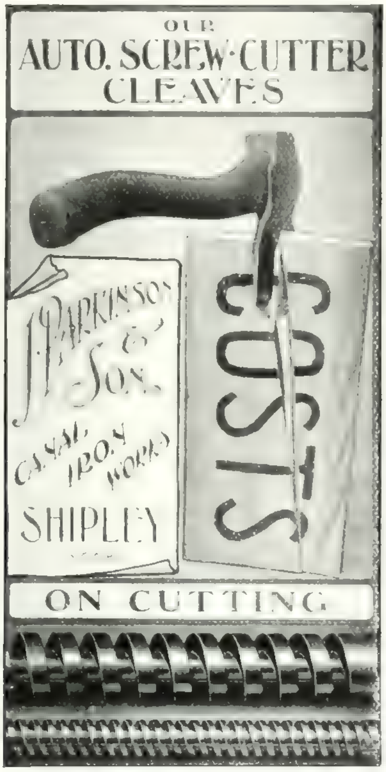

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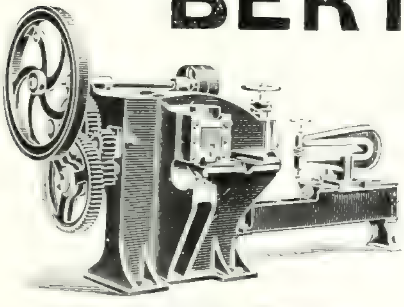
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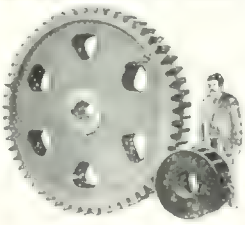

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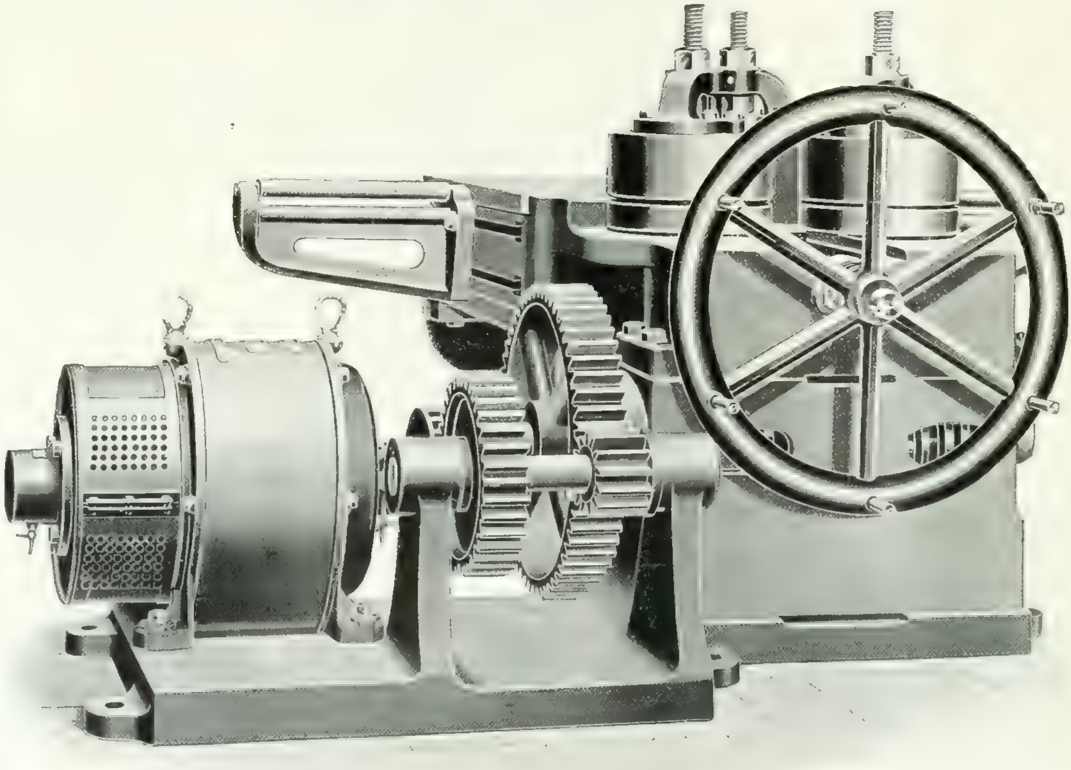

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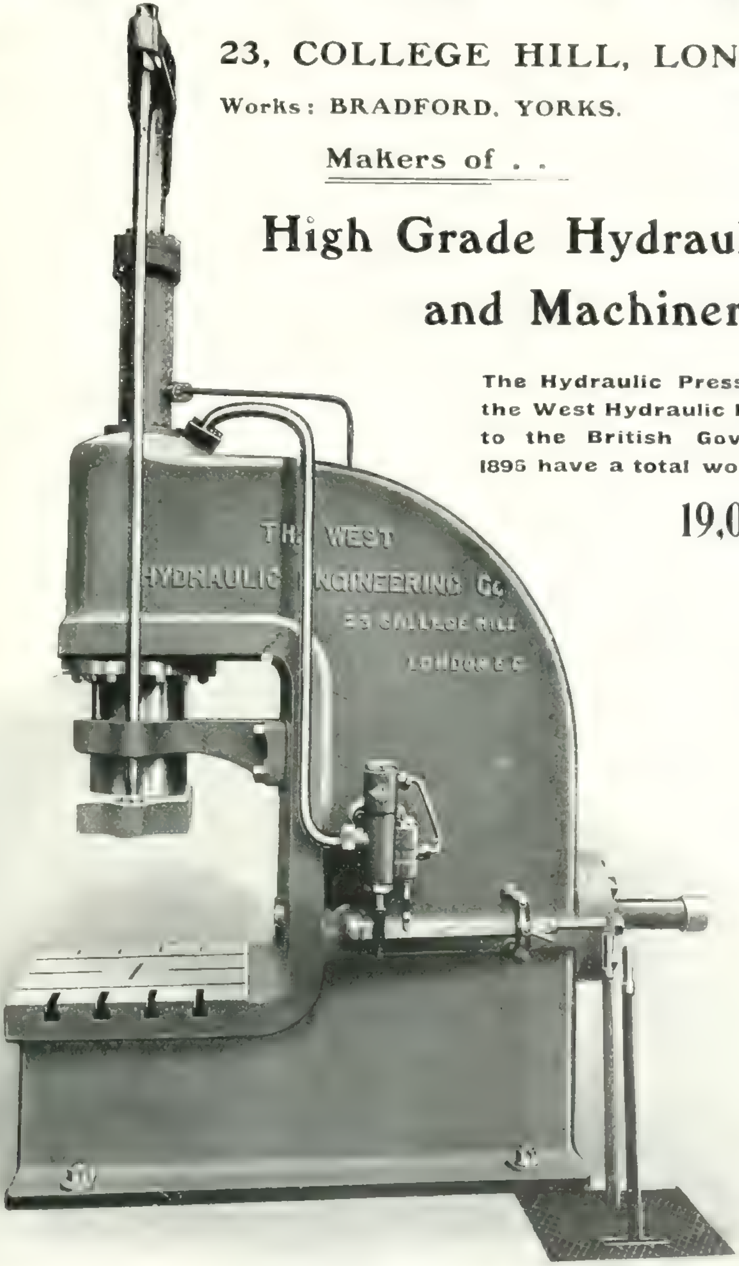

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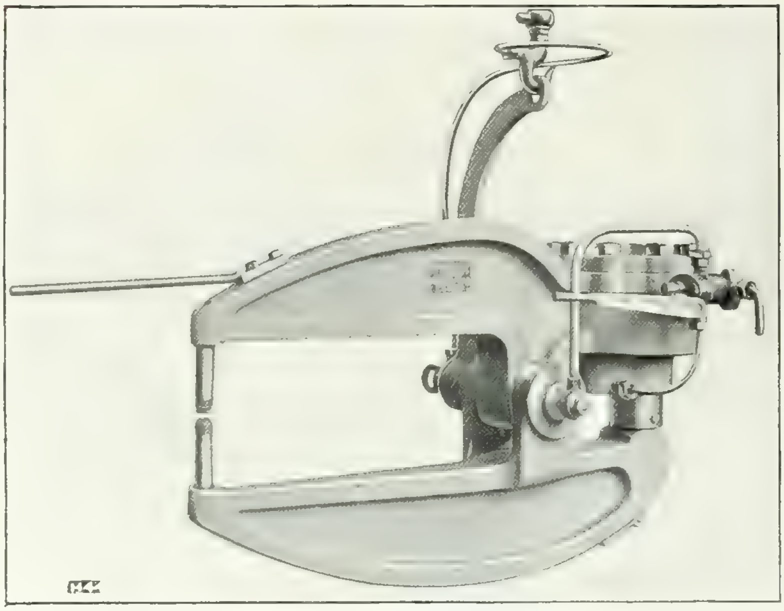

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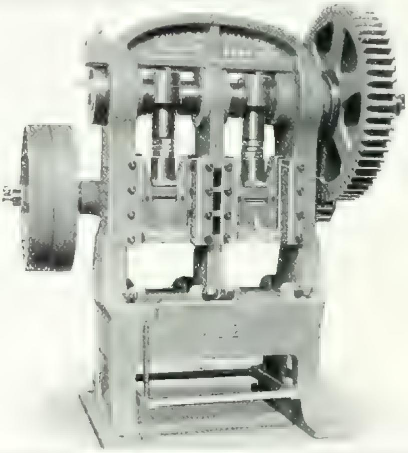

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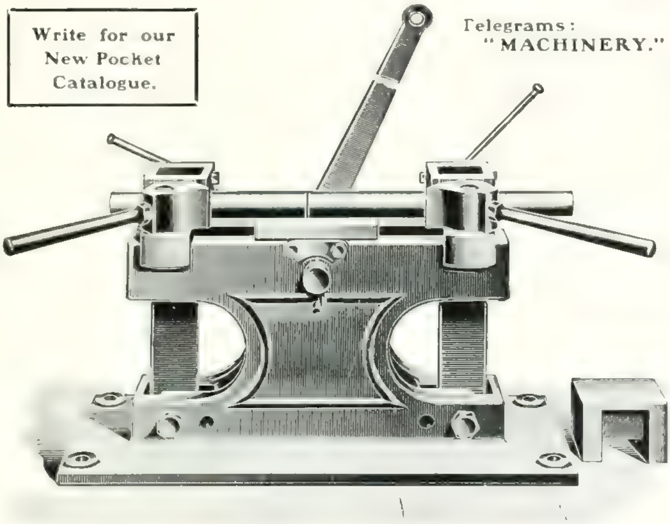

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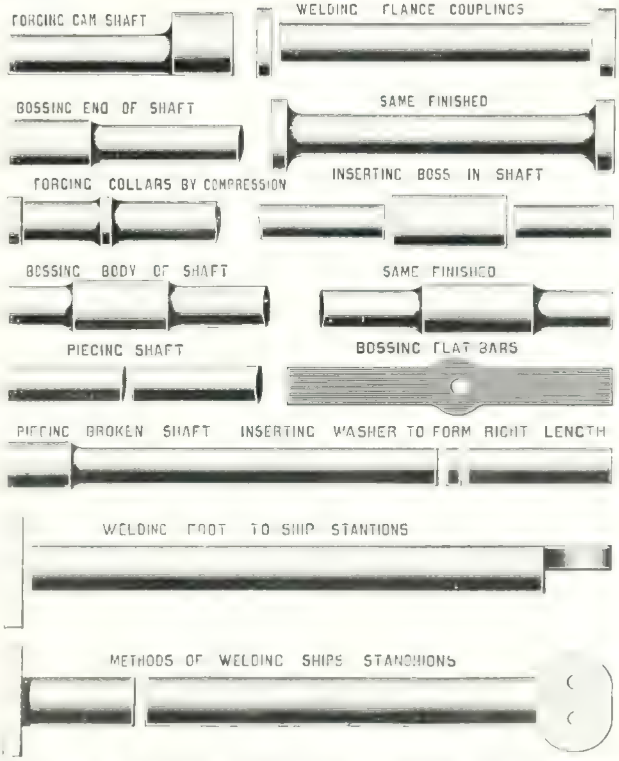

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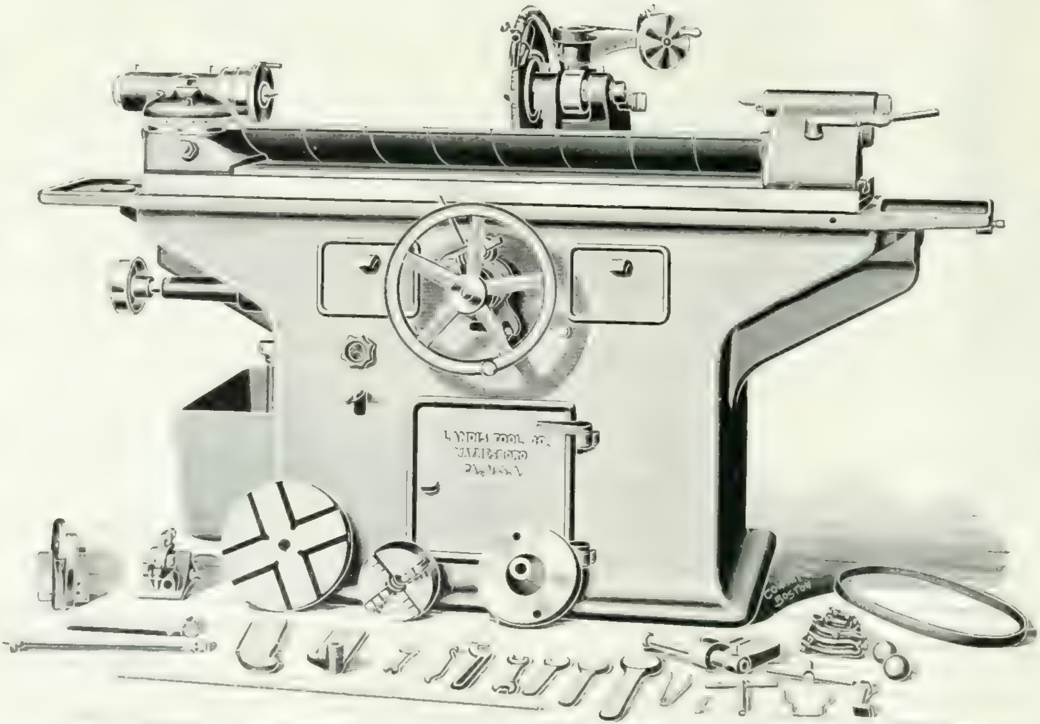

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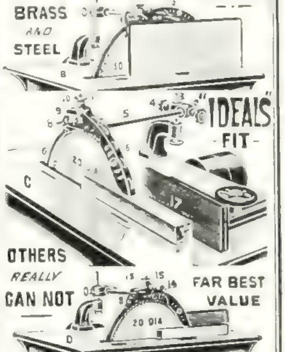

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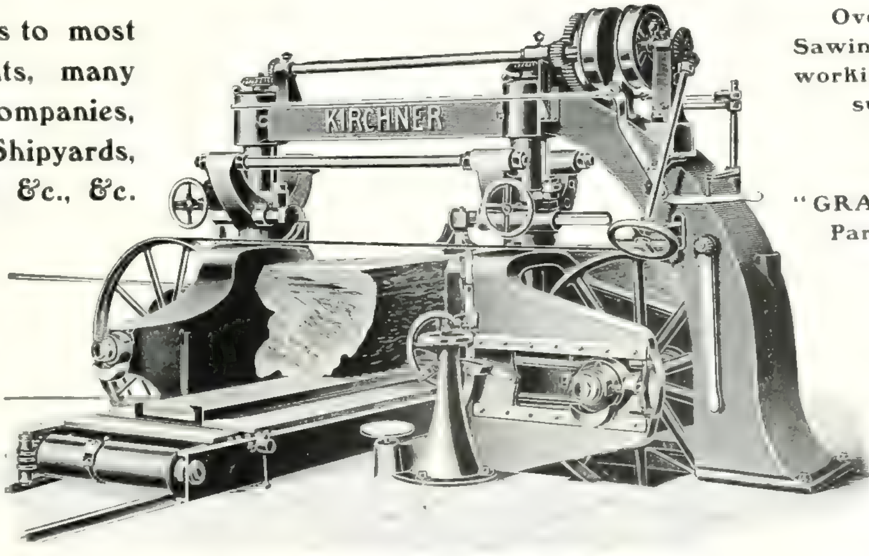

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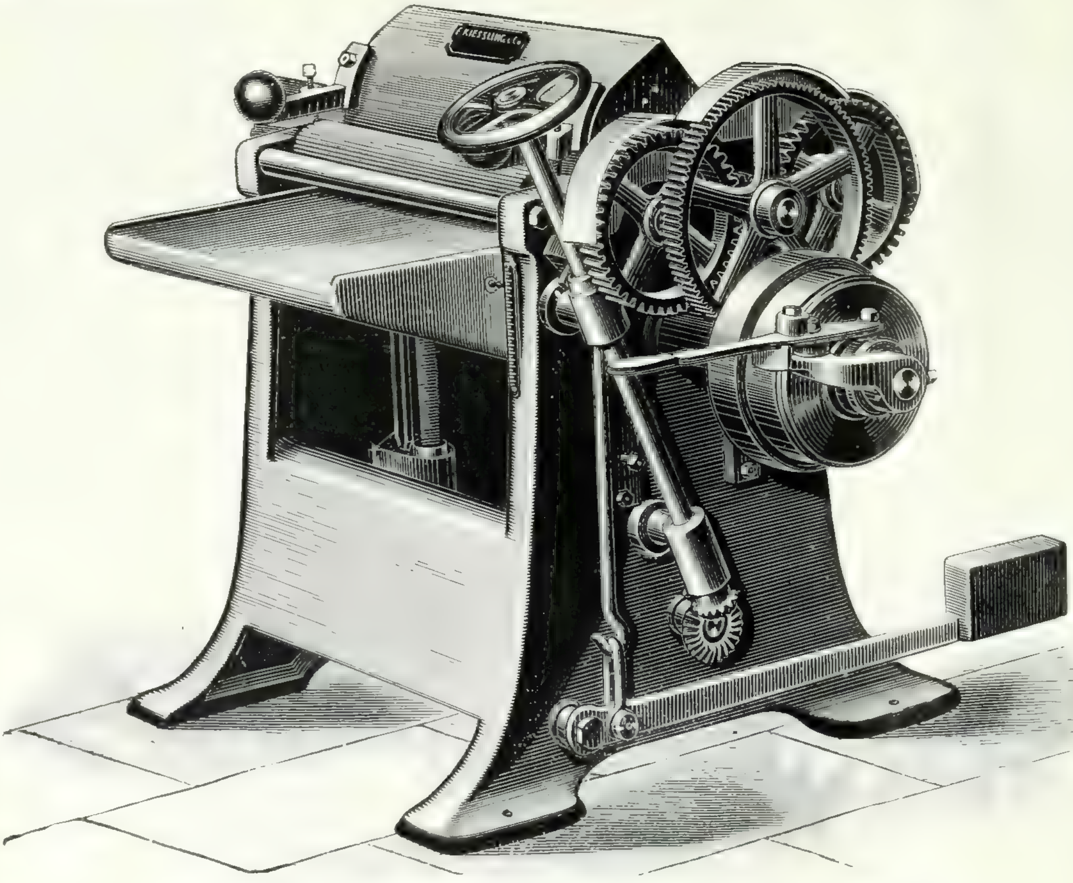

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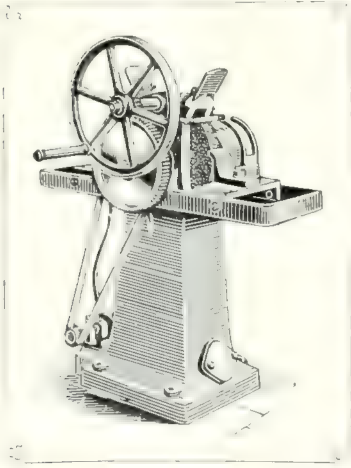

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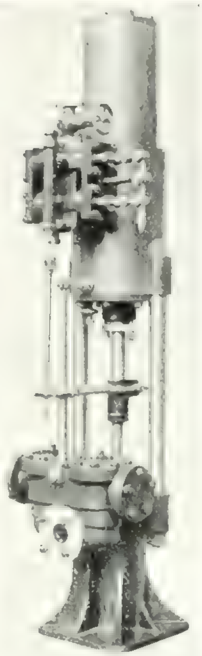

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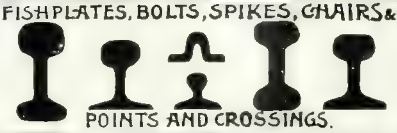

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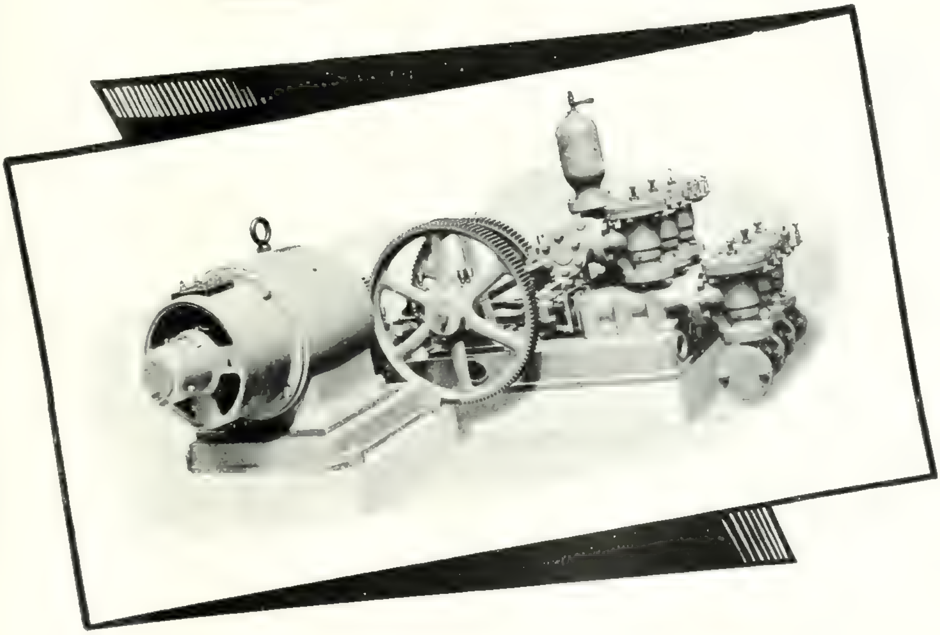

The . . . .
Illustration .
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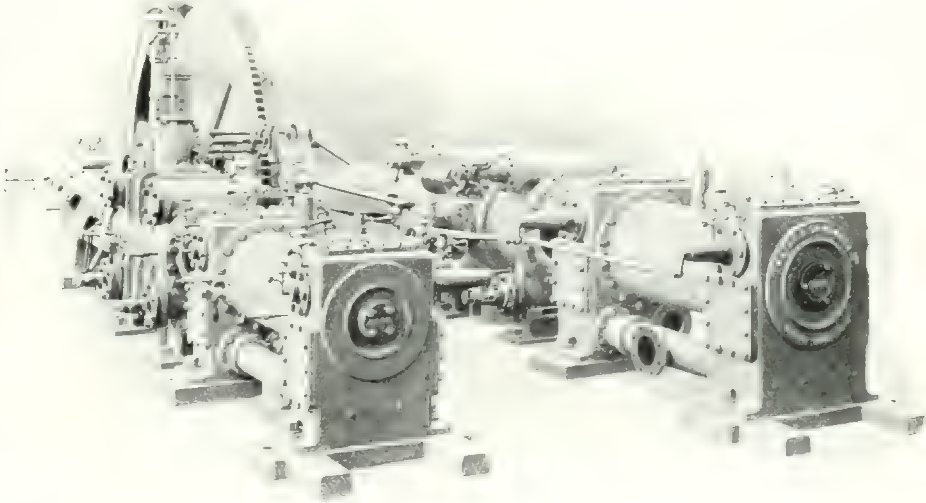

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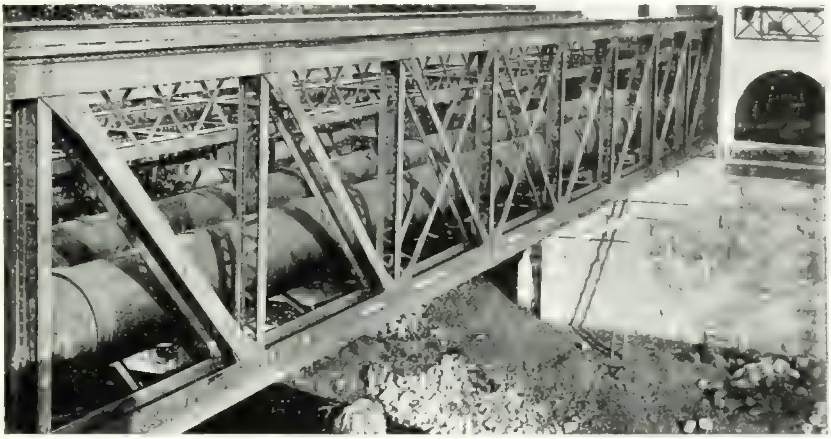

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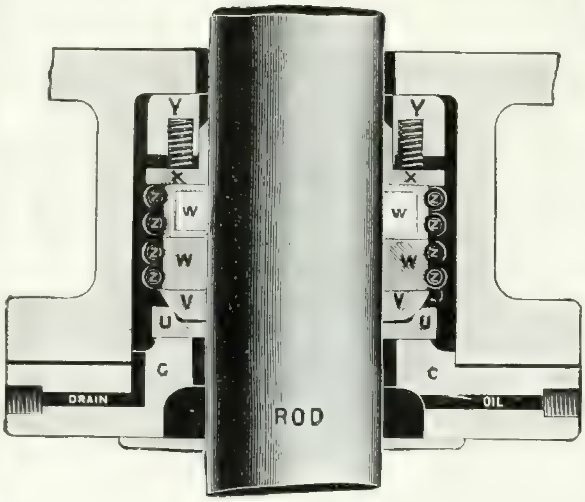

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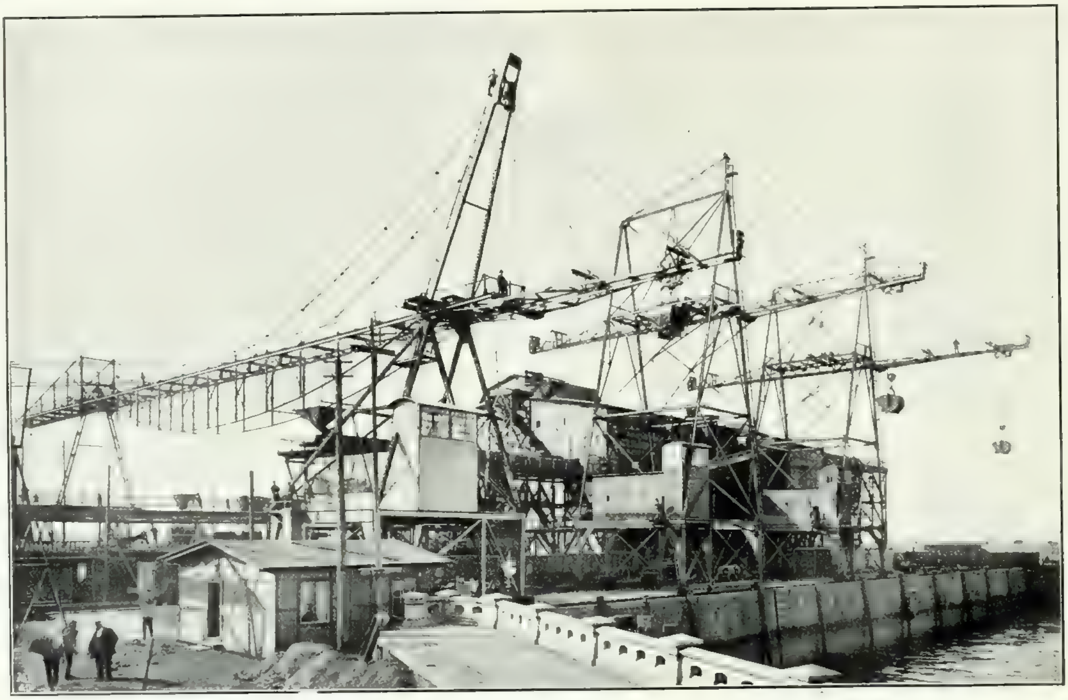

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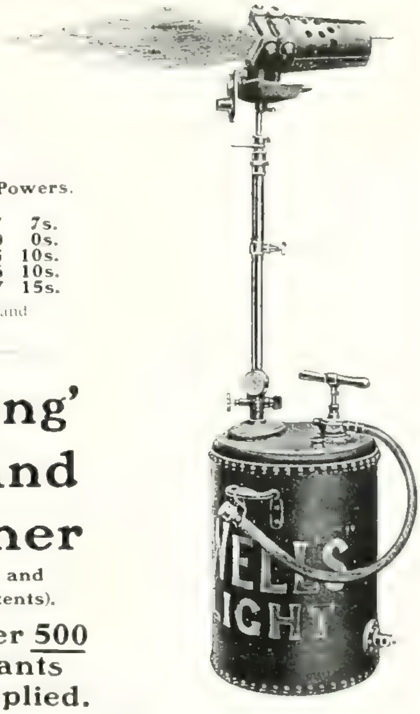

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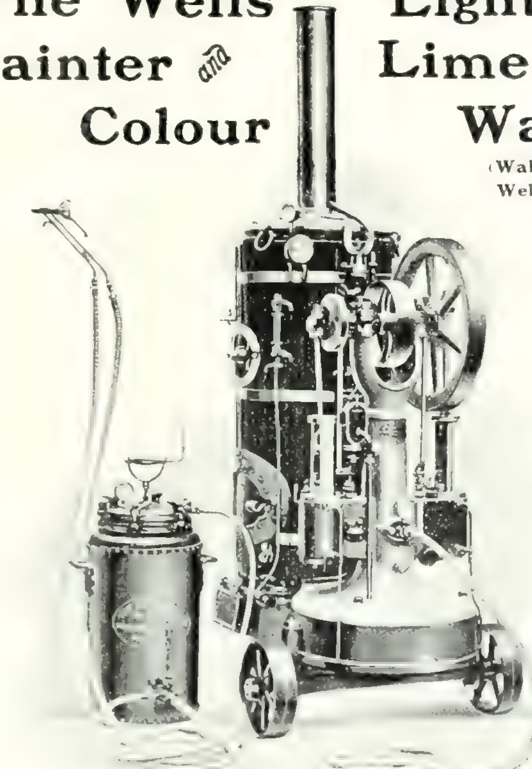

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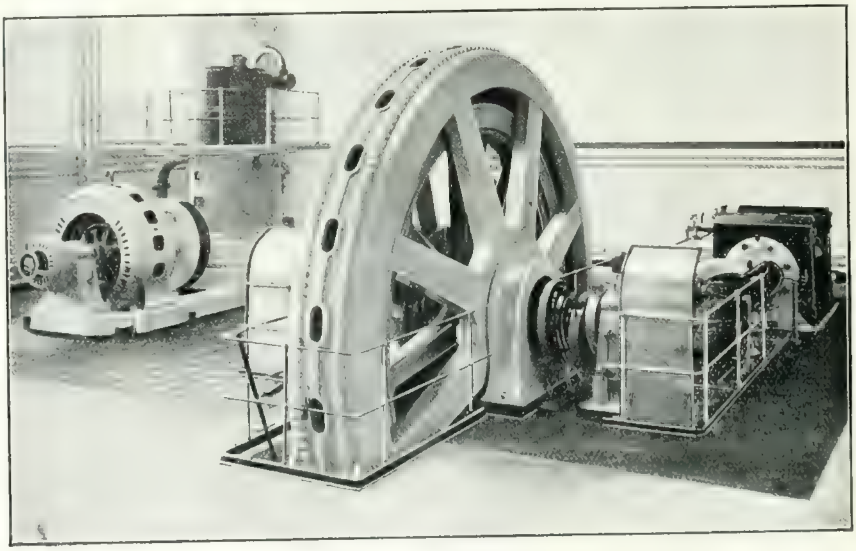

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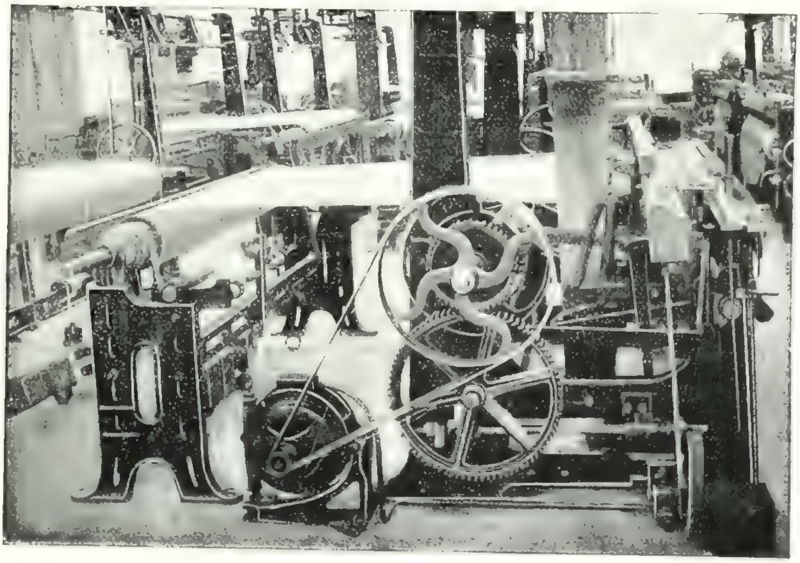

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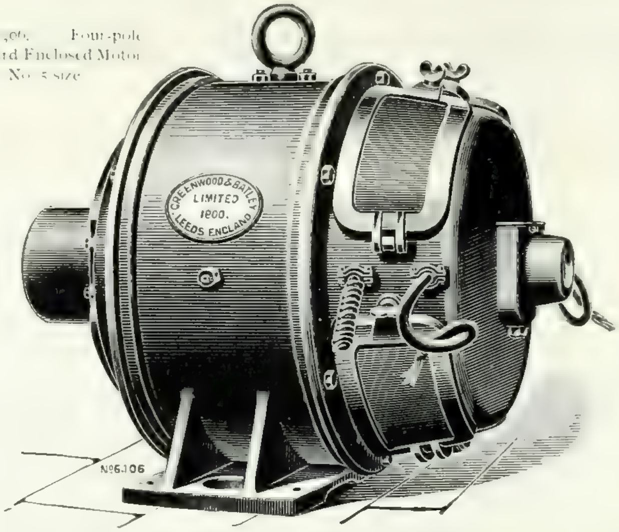
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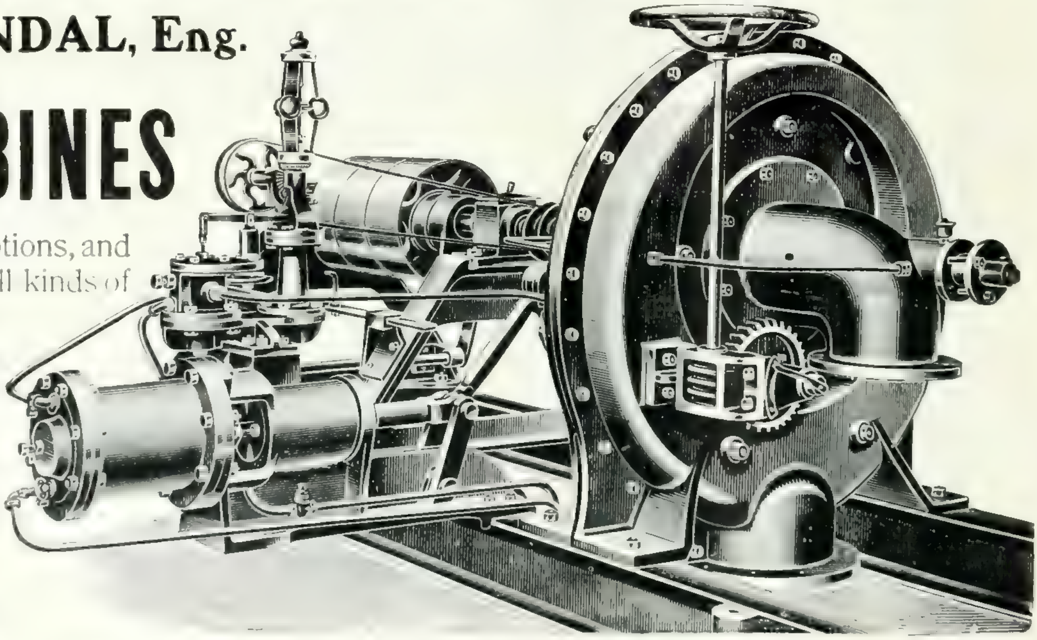

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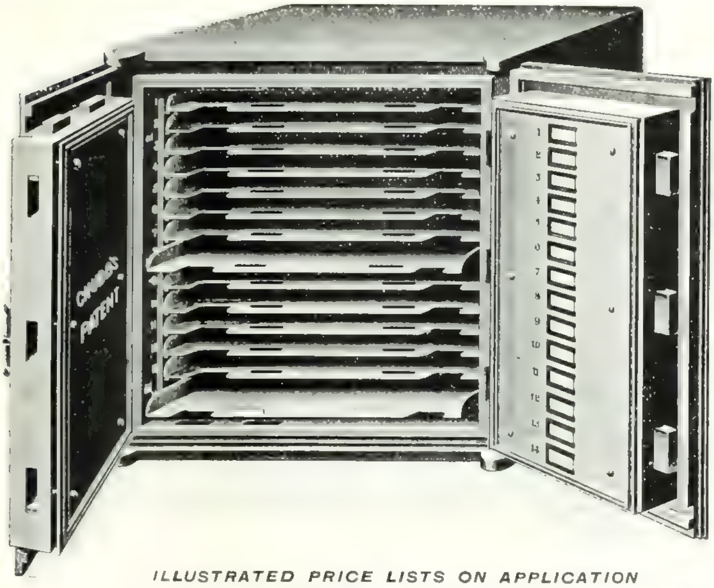

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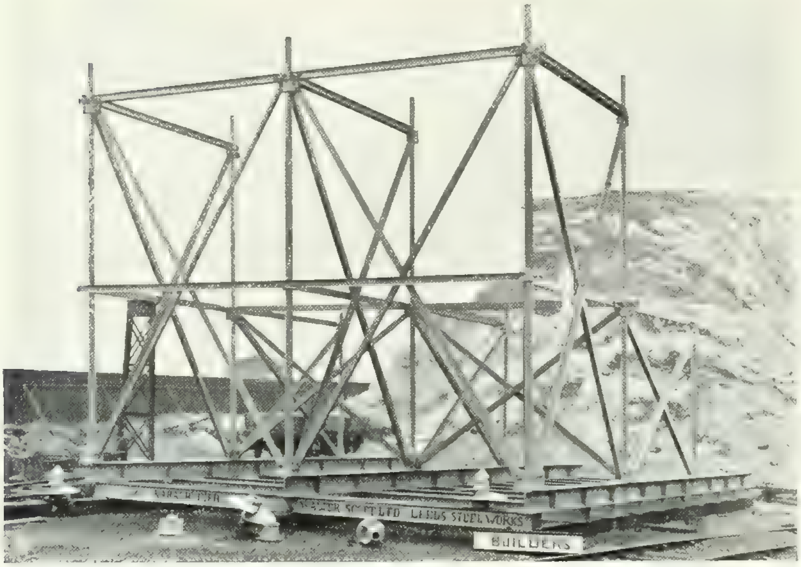

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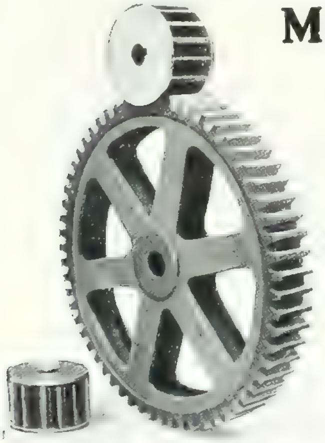

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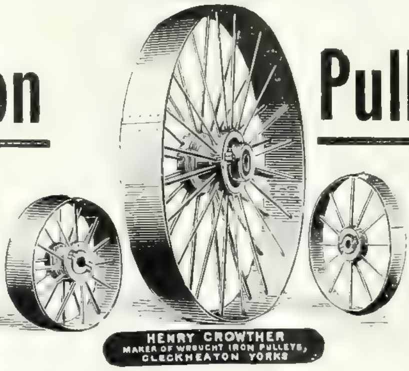

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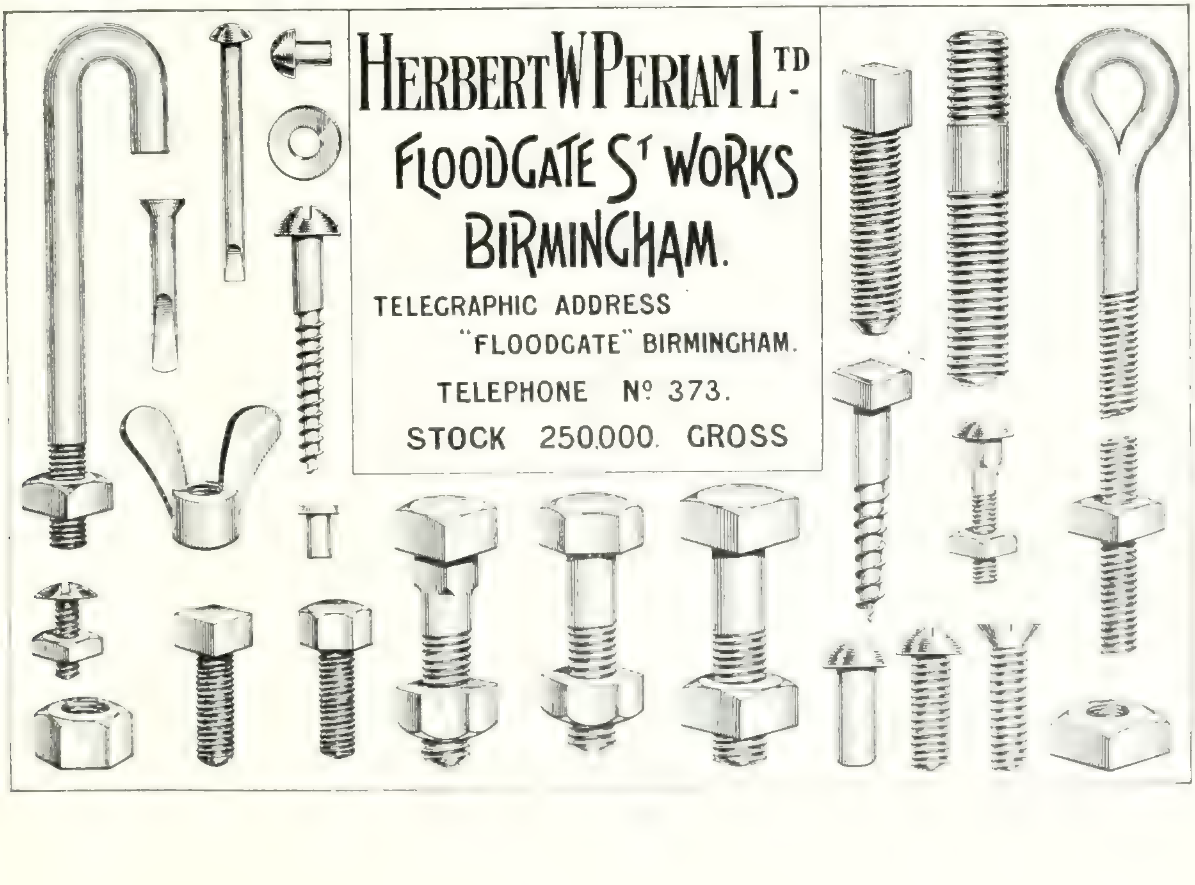

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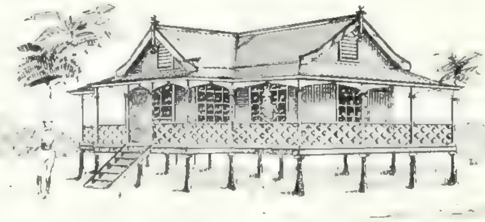

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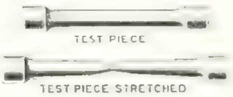

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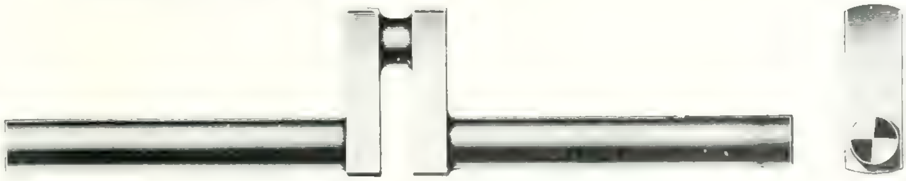

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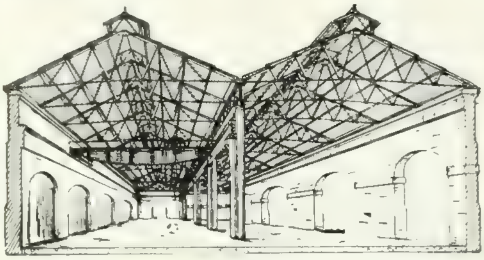

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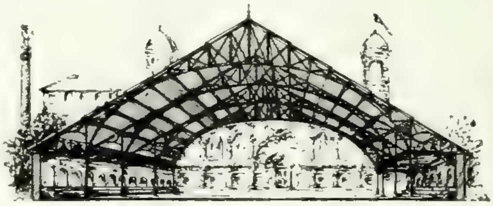

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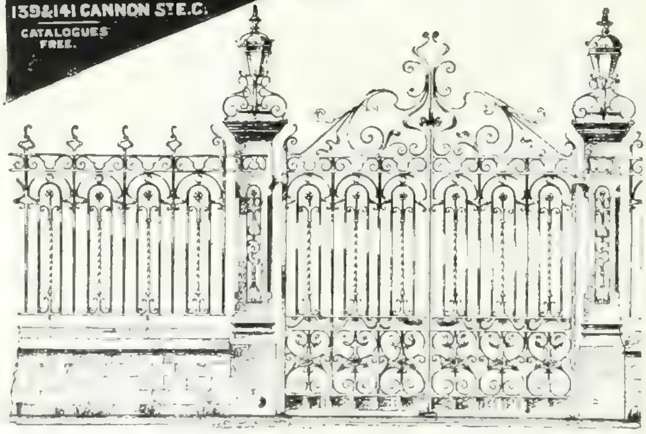

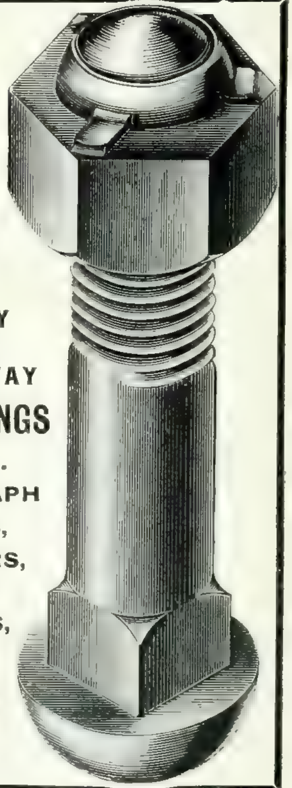

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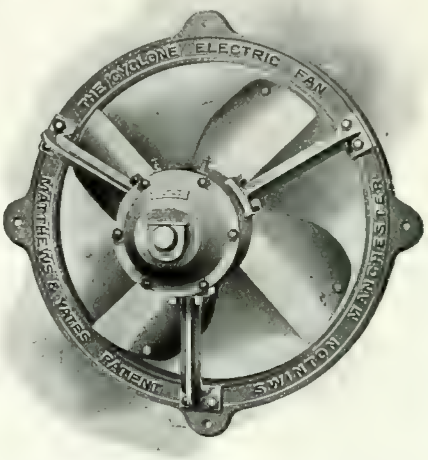

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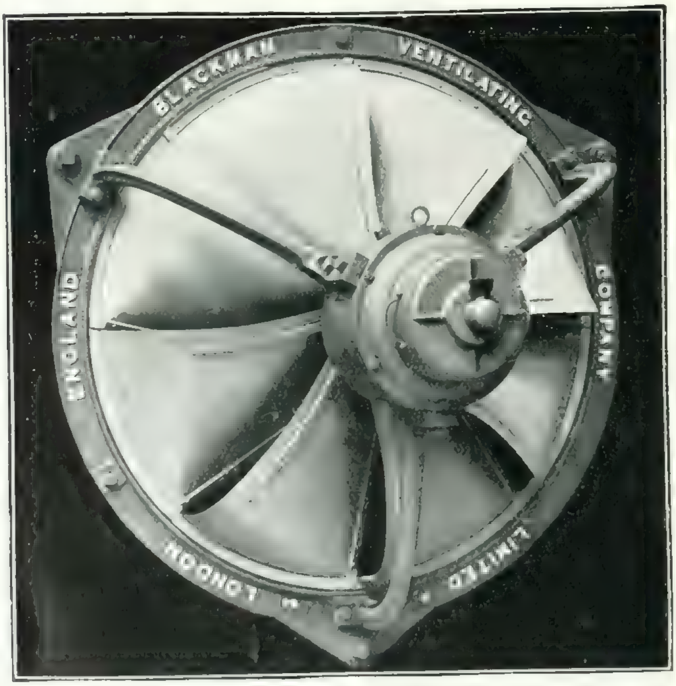

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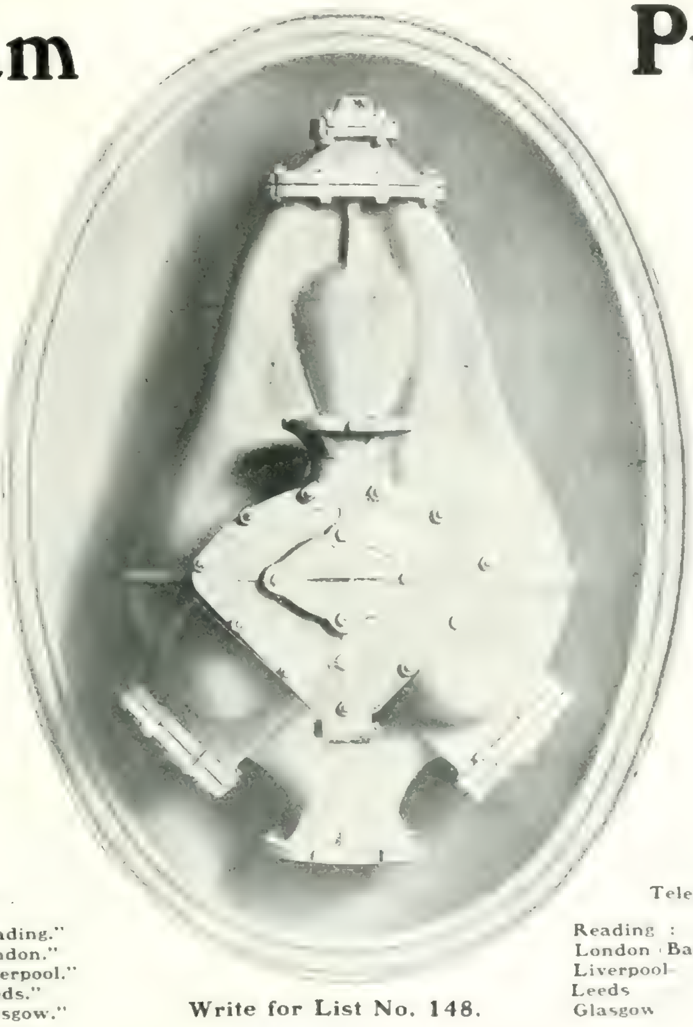

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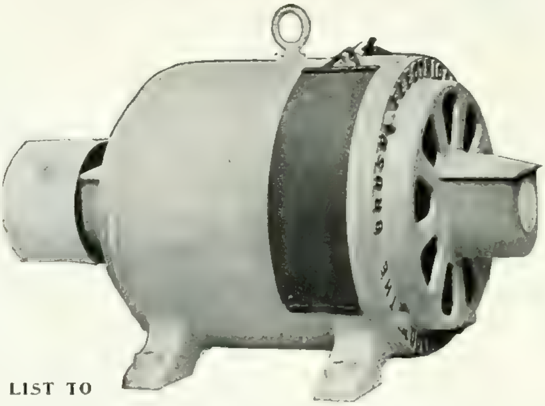

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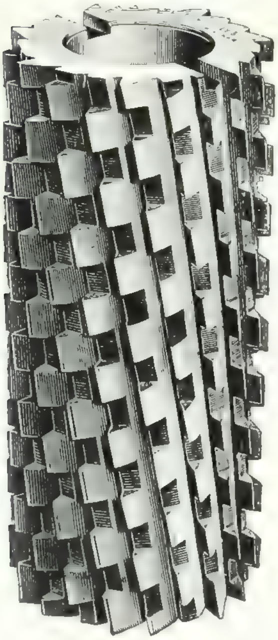

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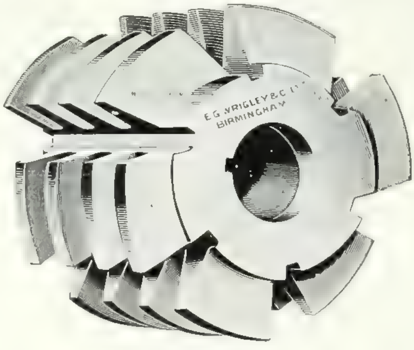

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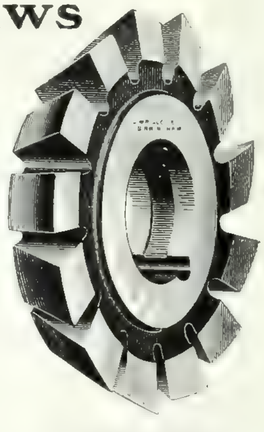

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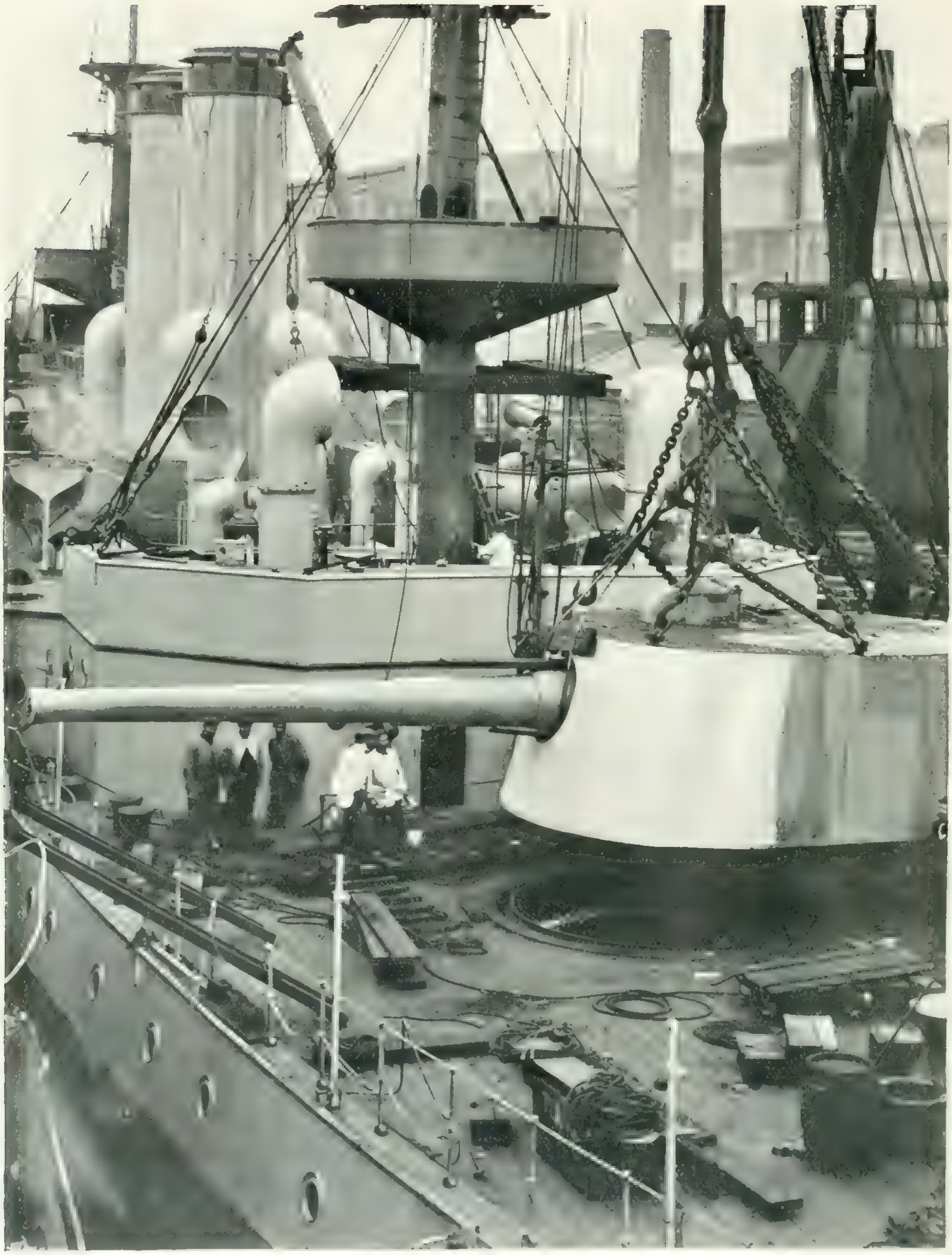

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VOL. I. LONDON, OCTOBER, 1902. NO. 4.

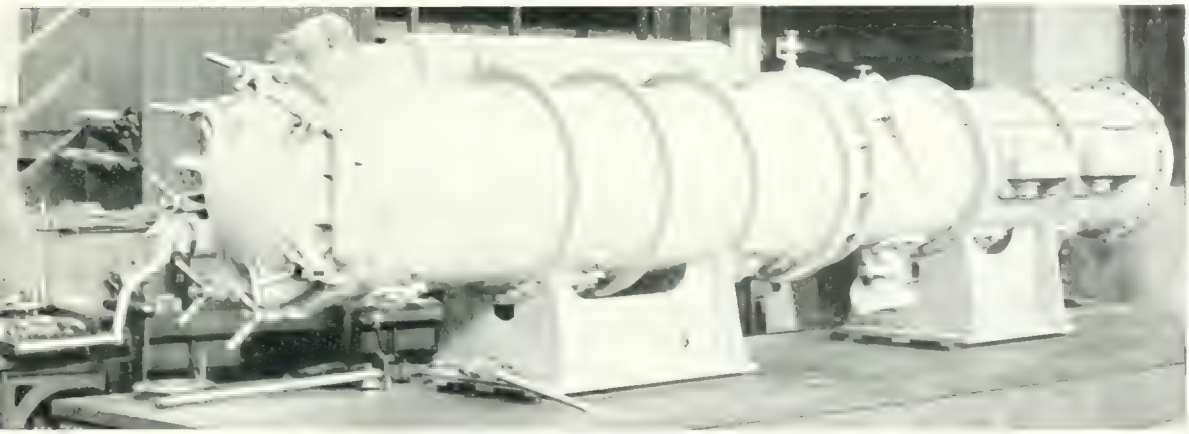
THE GUN v. THE ARMOUR PLATE.

BY

JOHN LEYLAND.

[illegible]

THE vital question of protection from attack is one of extraordinary interest; and, looked at from a naval or military point of view, it might take us back to very distant times in the history of humanity. It is, in effect, the necessary consequence of that eternal antagonism between the attack and the defence which is as old as humanity itself. It has also great modern importance in its special relation to the armouring of ships of war, because upon the defence that it is possible to give to them must depend their design and construction. The announcement made in May that the Lords of the Admiralty had witnessed at Messrs. Vickers' range at Eskmeals, near Barrow, trials against armour which reversed previous experience and were a total surprise, and the experiments with the *Belleisle*, make the question of the relation between the gun and the plate one of very great gravity and practical consequence. The purpose here is to show how the position stands. We were told that the



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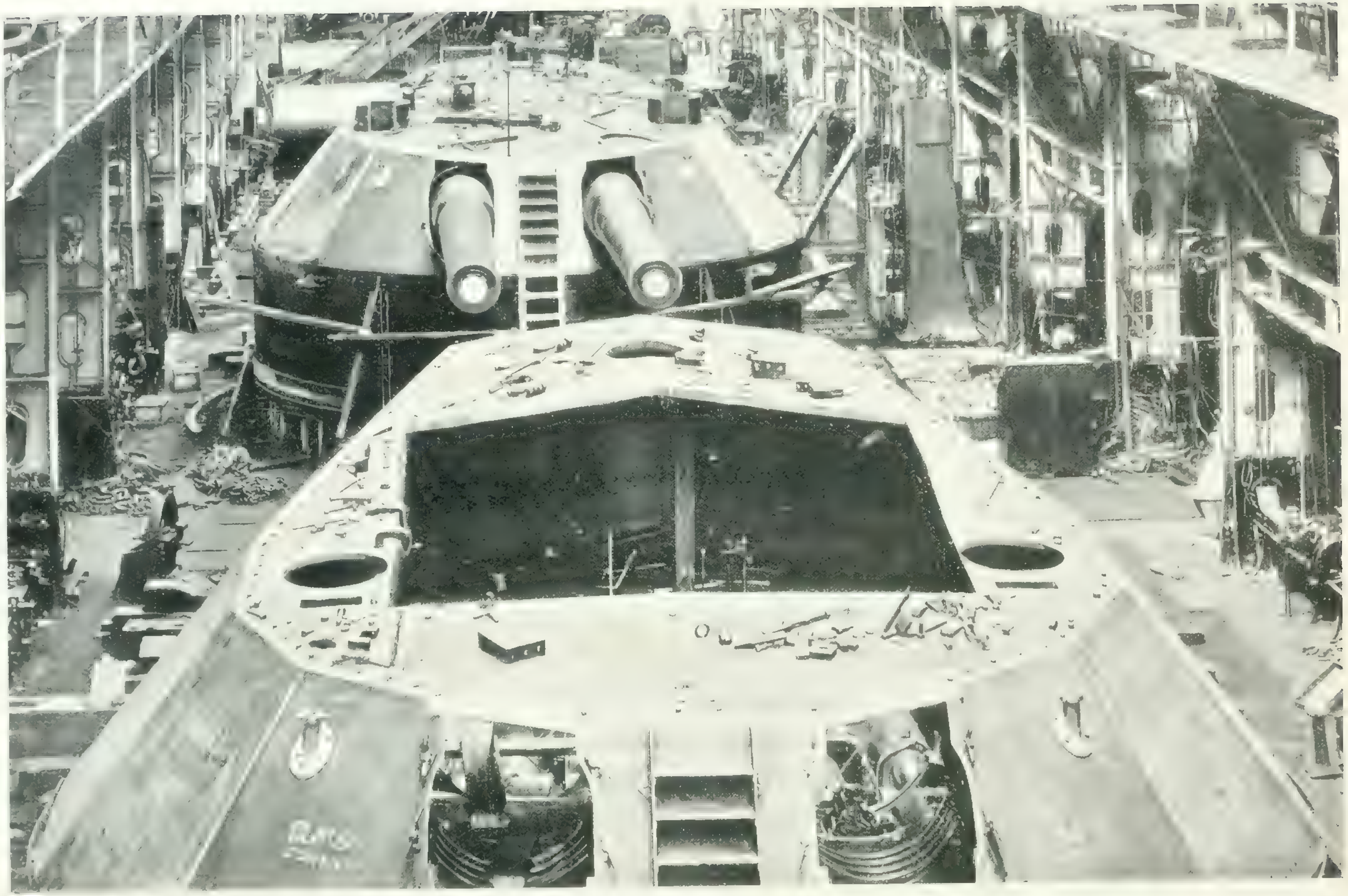

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A recent view in the works of Messrs. Armstrong, Whitworth and Co., Ltd.

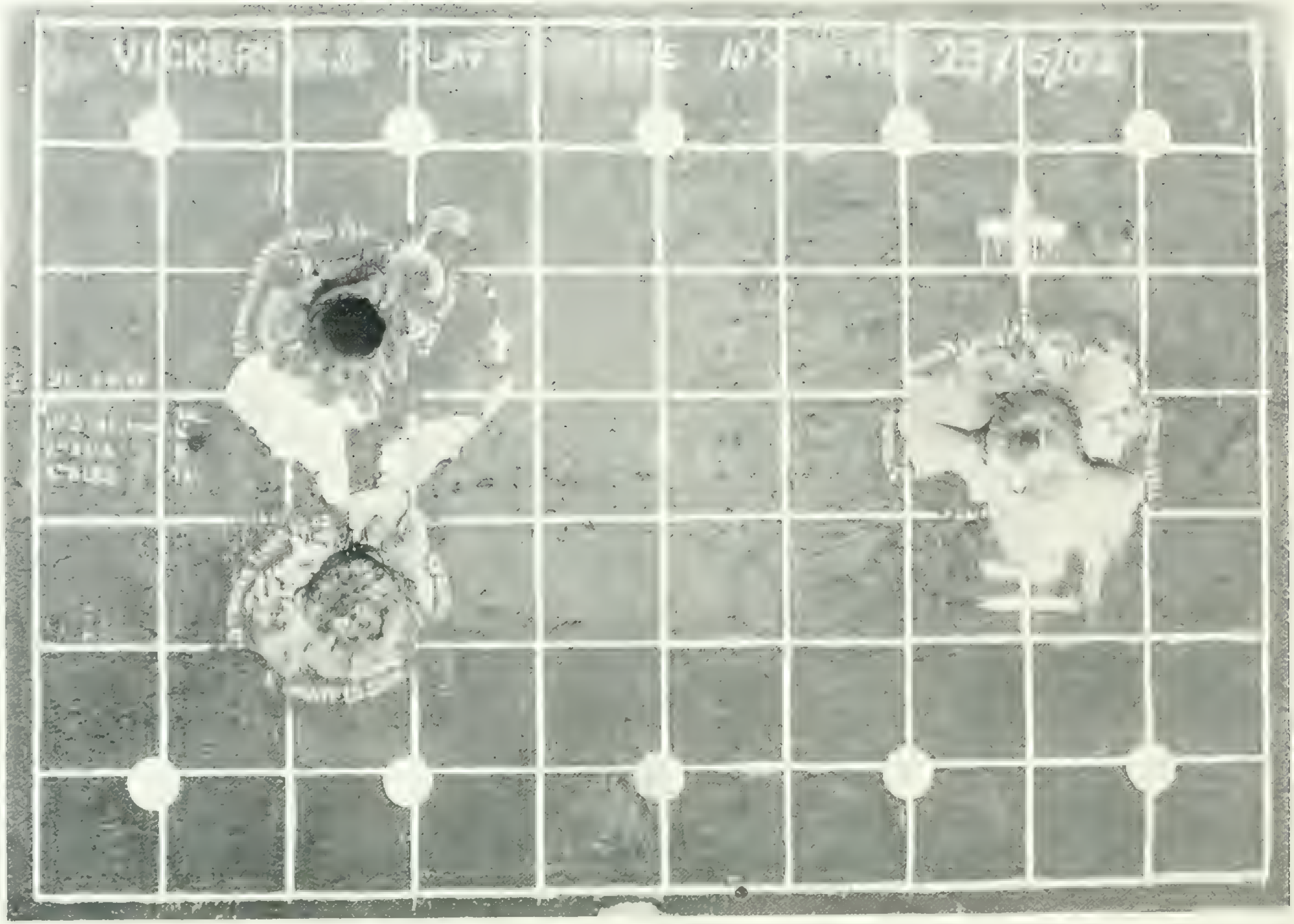
"Johnson cap" had enabled a 105 lb. armour-piercing shot of 6 in. calibre to completely perforate a 6-in. Krupp-cemented armour plate, being fired with a striking velocity of 1,971 foot-seconds (fig. 5, round 3); that the same cap had sent a 6-in. 105-lb. projectile, fired with a striking velocity of 2,799 foot-seconds, through a 12-in. plate of the same character (fig. 1, round 1); and, finally, that the same cap had carried a like shot completely through the same 12-in. plate with a striking velocity of 2,786 foot-seconds (fig. 2, round 4).

These astonishing results, and particularly the fact that a capped 6-in. projectile had twice completely perforated a 12-in. plate of the best Krupp armour, whereas an uncapped shot, with a similar striking velocity, had only penetrated 3 in., caused a veritable sensation. It was said that the Admiralty must have been very neglectful to overlook the merits of so important a device as the "Johnson cap," which could be fitted on board ship, and would give a gain in armour-piercing power of 30 per cent. Undoubtedly the cap had shown its usefulness for direct fire, and might be depended upon to give results analogous to those attained at Barrow in the case of projectiles striking within about 20 deg. of the normal. Beyond that angle the cap is, perhaps, of less value, but it must be remembered that a very large proportion of shots may be expected to strike at a near approach to a right angle with the face of the armour. It might be unfair, however, to censure the Admiralty for neglect in this matter. Whatever has been the case in the past, there can be little doubt that the present Board, which has now, with few changes, ruled affairs for several years, is very alert, and that it regards all new inventions and discoveries with an open mind. It was too readily assumed that the trials at Barrow were a revelation. As a matter of fact, those who were acquainted with the history of the struggle between the gun and the plate were not surprised to find such results recorded. For the capped armour-piercing shot—the *projectile coiffé*—was no new thing, and trials had been made with it during the previous eight years which must have placed in the hands of the Admiralty Board a good deal of information upon the subject. Until more is known it would not, therefore, be right to blame the Admiralty for having neglected a great opportunity.

The use of the cap is, in fact, only one part of the great problem arising out of the contest between the gun and the armour. Much damage may be done, and great demoralisation be caused on board a ship in action, by showers of weak common shell, but, in all modern ships, the protection of men is now carried to a high degree, and the final resort must be to the use of the armour-piercing projectile. The first *Belleisle* trials threw a great deal of light upon the disposition of men in our existing ships, and there can be little doubt that the practical experience gained would enable many lives to be saved in any future fleet action. But, after all, if a ship is to be effectually dealt with, it must be by means of penetrating the armour, and it seemed to be a teaching of the first *Belleisle* trials that the secondary armaments of the battleships of the *Majestic* and *Canopus* classes are for this purpose comparatively ineffective. Wherever ships are built exhaustive trials are now being conducted, all tending to improvement both in guns and armour.

Steel armour plates originally and for a long time proved very brittle, and gave small promise of success; but a quarter of a century ago steel in one form or another began to be adopted. In England great efforts were made to secure toughness, and the Sheffield firms of Cammell and Brown introduced what were termed compound or hard-faced plates, consisting of a hard steel face upon a soft wrought-iron back or foundation. Krupp began to make such plates at Essen on Wilson's system in 1891. Compound armour held the field from 1880 to about 1892, but the advantage over the improved steel was not conspicuous. A further improvement was due to the use of nickel as an ingredient in the steel, introduced by Schneider in 1890, and adopted for the British Navy in 1896. When compound armour was introduced, armour-piercing shot of cast-iron, chilled by the Palliser or some other similar process, were employed, and the plates were so successful that the heads of the Palliser projectiles were crushed, unless extraordinary striking energy was developed as compared with the resistance of the plate.

Thus the superiority rested temporarily with the plate; but, about the year 1896, when chrome-steel projectiles came in, hardened at the head by water or oil, the case was changed. The extreme



FIRST ROUND
SECOND ROUND

THIRD ROUND

RESULTS OBTAINED AFTER FIRST, SECOND, AND THIRD ROUNDS AT MESSRS. VICKERS, SONS AND MAXIM'S RANGE AT ESKMEALS, AGAINST A 12-IN. VICKERS K.C. PLATE, ILLUSTRATING THE ADVANTAGE OF THE "JOHNSON CAP." (FIG. I.)

(For details see opposite page.)

hardness, combined with toughness, which characterised the new shot, was so great that the piercing power was increased fully 20 per cent., and it generally happened that perforation was effected without any damage to the shot. Extraordinary efforts were consequently made in every direction to defeat the new projectile, and once more a swing of the pendulum occurred. Cemented plates were brought in, possessing the two qualities of hardness and toughness. Captain Tresidder discovered that by the application of a water jet to the hot metal a degree of hardness was produced which, in ordinary plunging, was prevented by the formation of steam, and Harvey, in America, perfected a process of carbonisation by contact with carbon at high temperature for several days, the face being finally water-hardened. A 10½-in. Harvey plate at Indian Head was successful against an 8-in. Carpenter steel shot of 250 lbs., with a velocity of 1,700 foot-seconds, and a perforating power of 14·8 in. of wrought iron. This plate, therefore, was much superior to the steel and compound plates then being supplied to the *Royal Sovereign* and other ships, and, at the same time, Schneider was making plates which approached the Harvey system in quality. The advantage gained was enormous, and on steel faces, hardened by the Harvey and Schneider processes, excellent projectiles broke up, and sometimes became disintegrated.

The Harvey process has been employed in the armour of a great many ships of war, but not long after it had been introduced Krupp came forward with the process which has now superseded it, and which, if we except the action of capped projectiles, has withstood the attack of armour-piercers. Krupp's plates, with which he began to experiment in 1893, are described by him as "one-side-hardened nickel steel plates" (*Einseitig gehärtete Nickelstahlplatten*), and are known in this country and in America as "Kruppised" or Krupp plates. Their extreme hardness is carried by a special process to a certain depth, while the back of the plate is very tough and enduring. When, in 1896, a trial of the new Krupp method was arranged, preliminary to the sale of the rights to the English firms of Brown, Cammell, and Vickers, and the French companies of Schneider, Châtillon, and Saint-Chamond, plates of various thicknesses were tested. The projectiles were of French manufacture, and English and French engineers were present. The result was perfectly satisfactory as showing the advantage gained by the process, and proved that enormous progress had been made. The consideration for the use of the patent was a certain royalty per ton for all plates manufactured. The process is most successful with plates up to 6 in. thickness, the effect for thicker plates being not so well ascertained. Every country recognised the advantage of the new method, and, by agreement, the Russian Government works were enabled to make the new plates. The Carnegie and Bethlehem Companies obtained the rights in the United States, and in Austria the Witkowitz firm. The Terni Works, in Italy, also make a special steel which seems to be the same or closely analogous. The resistance of Krupp plates, with their hard surface, breaks up the point and head of the ogival-headed projectile, and their extreme toughness offers great resistance to punching and cracking. Results have also been attained which justify the belief that a Krupp plate is equal to a compound plate of double its thickness. It is not necessary to point out how great was the effect of this new system of hardening steel upon the protection of ships. It has enabled thinner armour to be used, and the area covered to be more extensive; and it may be said that at the present time a 12-in. gun of 50 tons fairly matches a 12-in. plate.

The plate has thus remained victorious over the projectile, and the eminent authority who

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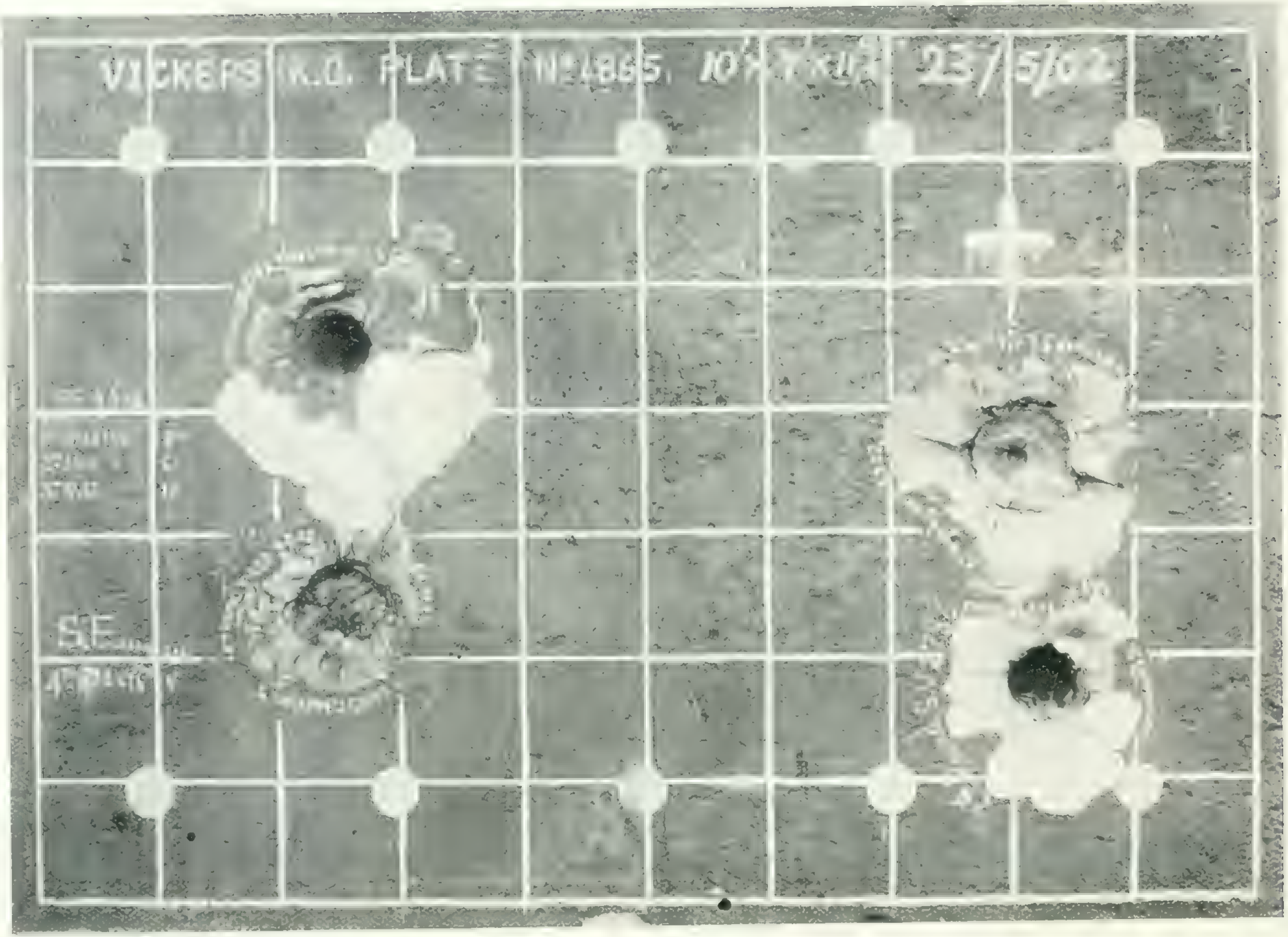
[illegible] Johnson cap [illegible] [illegible] capped [illegible] [illegible] H [illegible] V. [illegible] Diameter of [illegible] back 1¾ in., otherwise it would have gone completely through. Striking velocity, 2,700 foot-seconds; striking energy, 5,705 foot-tons.

Second round [illegible] Johnson armour-piercing shot, without cap, weighing 100 lbs. Projectile completely broken up. Penetration about [illegible] plate. Extent of injury [illegible] H [illegible] V. No cracks. Diameter of portion of shot [illegible] bulge at back, or displacement of backing. Striking velocity, 2,820 foot-seconds; striking energy, [illegible]

Third round — 7·5 in. Johnson armour-piercing capped shell, weighing [illegible] P [illegible] 2 in. of core, remained in plate. It was not, however, fused in as in Round 2, for a feeler could be inserted in many places round the periphery up to 7 in. from face of plate. Penetration to front end of core was 5 in., if, therefore, the point preserved its profile, the total penetration would be 9¼ in. Base portion set up and part flowed in molten state into the front of core, moulding itself to its contour. Extent of injury, 23·5 in. H × [illegible] V. [illegible]



FIRST ROUND
SECOND ROUND

THIRD ROUND
FOURTH ROUND

RESULTS OBTAINED AFTER FOURTH ROUND AGAINST A 12-IN. VICKERS K.C. PLATE, ILLUSTRATING THE ADVANTAGE OF THE "JOHNSON CAP." (FIG. 2.)

(For details see opposite page.)

writes upon armour in the "Naval Annual" has said that, in the case of all new ships with 6-in. Krupp armour, equal to from 15 in. to 18 in. of wrought iron, and impenetrable to our best 6-in. gun at quite short ranges, such as 1,500 yards, it is evident that more powerful guns are required, having a penetration of from 18 to 20 in. of wrought iron at 2,000 yards. "Even if 3,000 foot-seconds muzzle velocity could be attained with a service charge from the 6-in. gun, as has been promised by some sanguine prophets, this would not suffice, and a more powerful gun is an absolute necessity." Incidentally something may be said here concerning some of the guns which now, in splendid protective mountings, are being placed in our own and foreign ships. The new Vickers 6-in. gun, with which a metal cartridge is not used, possesses a perforation of wrought iron at the muzzle of 21 in., and in the 7·5-in. gun which is being placed in the new ships, the figure is increased to 27·4 in. At the Eskmeals trials the firing with the latter gun represented the rate of eight aimed rounds a minute. The penetration at the muzzle of the Elswick 6-in. gun is given as 21·3 in., 23·2 in., and 25·15 in. in the case of the 40, 45, and 50-calibre pieces, while for the same proportionate length of gun, in the case of the 7·5-in., the figures are 26·75, 29·10, and 31·65 in. It is obvious, however, that at ranges such as have been indicated, the 6-in. gun could not suffice, and hence the improvements in that weapon and the introduction of guns of larger calibre. The penetration has increased more than 50 per cent. during the last few years, but the protection has gone up quite 100 per cent. In the case of heavy guns the advance has also been enormous. The 13·5-in. guns of the *Royal Sovereign* are inferior in perforating power to the 12-in. guns of the *Majestic*, and still more to those of the *Implacable* and the French *Suffren*, but these again are outclassed by the like guns of the Russian *Tsarevitch* and the American *Georgia*. The Armstrong 12-in. guns in the Elswick tables are given a penetration of wrought iron at the muzzle of 42·6 in. (40-calibre), 46·7 in. (45-calibre), and 50·9 (50-calibre), thus illustrating the prodigious advances made.

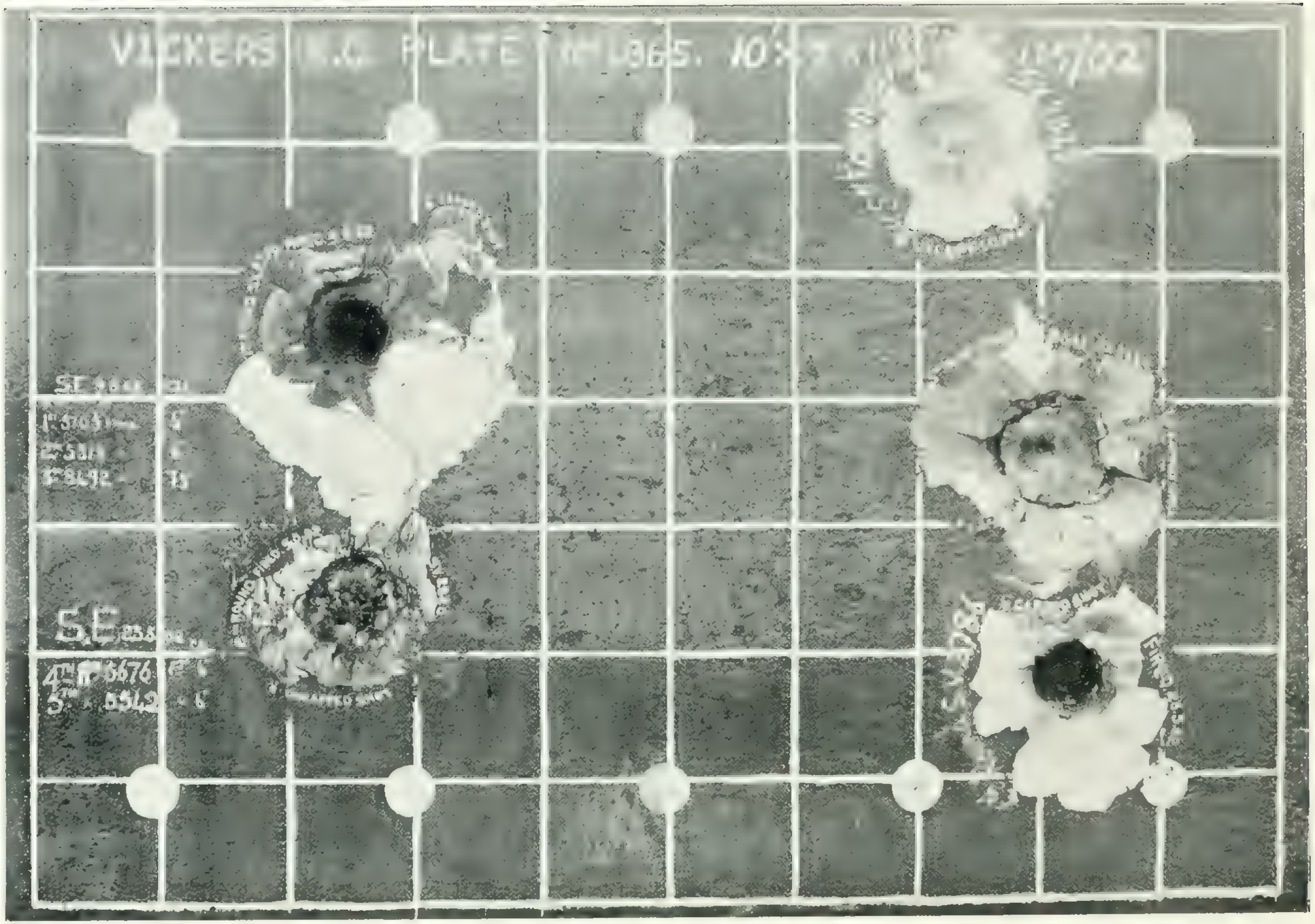
Returning now to the armour plates attacked by modern guns, it deserves to be mentioned that Krupp non-cemented plates made by Messrs. Cammell have behaved very well. A 4-in. plate defeated a 4·7-in. shot with a velocity of 1,813 foot-seconds and a penetrating power of 9 in. Sir W. G. Armstrong, Whitworth and Co. also presented at Whale Island, in April, 1901, three 4-in. non-cemented plates, which were tested with 45-lb. armour-piercing projectiles with a striking velocity of about 1,635 foot-seconds, from a 4·7-in. gun. Three shots were fired at each plate, and the maximum penetration was just over 1 in., without bulge or cracks, while the projectiles were shattered by the impact.

In these remarks, however, as to the contest between the gun and the plate, giving the victory to the latter, there has been no regard to the capped projectile, and the success which was referred to at the beginning may suggest that perhaps the cap will again bring about a swing of the pendulum, by adding new power to the projectile, unless, indeed, some "de-capping" device, such as has been proposed, should be introduced. The value of cemented plates is found in the action of their surfaces, since these, by their extreme hardness, determine the fracture of the attacking projectile before it can reach the softer ordinary steel. It is a fact, however, that, if the projectile can make a hole through the hardened part sufficiently deep, it rarely breaks up, and has a good chance of passing through. A trial took place at Shoeburyness towards the end of 1891, in which a plate resisted the attack of a projectile, but, when a thin coating of iron had been placed in front of the plate, the same projectile passed completely through. The fact was considered curious, and theoretically might perhaps be difficult to explain, but it was soon suggested to many minds that, if the soft metal plate enabled the projectile to penetrate the steel, a cap of the same material might with advantage be added to the projectile itself.

It may be concluded that the breaking up of

[illegible]

wards, and the skin-plate was bulged out over an inch, till it came in contact with the large iron plate washer against which the large nut on the [illegible]



FIRST ROUND
SECOND ROUND

FIFTH ROUND
THIRD ROUND
FOURTH ROUND

RESULTS OBTAINED AFTER FIFTH ROUND AGAINST A 12-IN. VICKERS K.C. PLATE, ILLUSTRATING THE ADVANTAGE OF THE "JOHNSON CAP." (FIG. 3.)

(For details see opposite page.)

the ordinary shot upon impact with a cemented plate results instantaneously with the shock, while the pressure of the cap has for its effect to give an appreciable degree of duration to the attack, thus permitting the ogival head of the projectile to reach a zone of softer metal, and to check in the projectile itself those vibrations which lead to fracture. In short, the soft cap protects the hard point of the shell, and holds it in position while its work is in progress. Admiral Makaroff, the eminent Russian officer, undertook in 1894 a series of trials with armour plates and special projectiles, which were described at the time as being manufactured by a secret process, and were called "magnetic." It was soon divined, however, that the word "magnetic" was intended to conceal their true character, and that they were in fact capped shot. The concealment of the projectile from view suggested the application of some visible device, and screens were employed which might catch anything detached from the shot, while it was stated that the process was applied to Holtzer projectiles, a circumstance which seemed to point to a mechanical rather than a metallurgical process. The trials took place at Ochta, on June 28th, 1894, when two Harvey-Tresidder plates, 8 ft. square and 6 in. thick, were furnished severally by Brown and Cammell, and one of the same dimensions 10 in. thick by Brown. These were attacked by 6-in. projectiles from an Obukhoff 45-calibre gun, the striking velocity for the 6-in. plates being about 1,850 foot-seconds, and for the 10-in. plate 2,400 foot-seconds. Owing to the curve of the plate, the angle of impact was from 8 deg. to 10 deg. from the normal. The projectiles were made at the Putiloff works, and, while those of the ordinary class broke up, the "secret-process" or "magnetic" shot perforated the plates direct, in one case striking at about 25 deg. from the normal, though oblique impact failed against the Cammell plate. With the Brown 6-in. plate these capped shot went through in every case, though one was broken up, while the ordinary projectiles were fractured, but one of them caused five or six cracks. In the case of Cammell's 6-in. plate, two of the capped shot were pulverised, but these struck at 25 deg. from the normal. At 20 deg. one of the capped shot broke up, but penetrated to a depth of 2·3 in., and one which hit at 15 deg. went through and broke the plate. Another, within 10 deg. of the normal, completely perforated. In the attack upon Brown's 10-in. plate, two capped shots went through at 8 deg. from the normal. The cap did not, in every instance, save the shot from fracture, but the penetration was greatly increased even when it broke, and it enabled the shot to perforate treated plates in conditions in which uncapped shot were totally defeated. Trials have shown that it is difficult to depend upon the effect of capped projectiles when the impact is at a considerable angle, and if oblique fire should play a large part, it may be surmised that the application of the cap might often be ineffective.

Projectiles of this class were advocated by Mr. Hadfield, Colonel Bainbridge, and others, and it was stated on good authority that comparative tests with Wheeler and Krupp projectiles were made in Germany, and that the latter proved themselves as good as the former. Mr. Isaac G. Johnson, of Spuyten Deeyvil, U.S.A., worked out his plan with considerable success. He used a special steel, and fitted his cap to a solid projectile. On April 30th, 1896, a capped 6-in. 100-lb. shot perforated a 7-in. reforged Harveyized Carnegie plate. Other successes followed, and the trials were watched with considerable interest. In France, Holtzer and Saint-Chamond projectiles were tried, in which the cap was applied hot and shrunk on the ogival head, or mechanically attached. The "Johnson cap" has been attached by means of a groove near the point, while Messrs. Hadfield employ a rib on the shot, also near the point.

An important trial of a special Beardmore 6-in. plate at Messrs. Vickers' range in October, 1891, threw clear light upon the value of the cap, and foreshadowed the success of last May, which has been alluded to. The projectile was an Elswick armour-piercer of 100 lbs., and in

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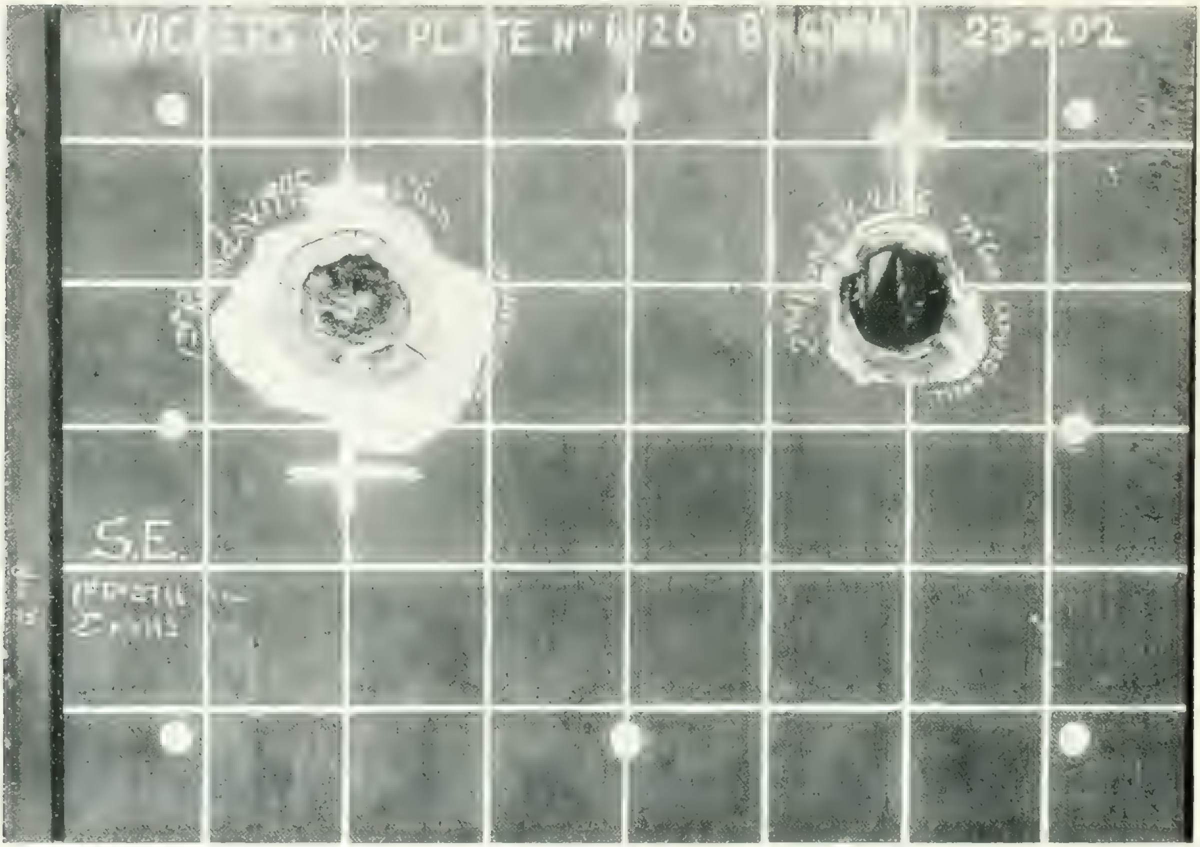
[illegible]

[illegible] that now a feeler can be inserted outside the shell for a distance of 11¾ in., showing that this capped shell must have nearly, if not quite, perforated the plate.

the first three rounds, in which the highest power resulted from a striking velocity of 2,177 foot-seconds and 3,280 foot-tons striking energy, with a penetration of wrought iron of 15·7 in. by Tresidder's formula, the projectiles were completely broken up, and no cracks resulted in the plate. In the fourth round, with a striking velocity of 2,261 foot-seconds and striking energy of 3,550 foot-tons, the point of the projectile just broke through. In the last round, with a capped projectile (105·9 lbs.), the striking velocity being reduced to 1,945 foot-seconds, the striking energy to 2,778 foot-tons, and the penetration of wrought iron to 13·8 in., the projectile completely perforated the plate undamaged, and passed through the backing to



FIRST ROUND SECOND ROUND

RESULTS OBTAINED AFTER A FIRST AND SECOND ROUND AGAINST A 6-IN. VICKERS K.C. PLATE, ILLUSTRATING THE ADVANTAGE OF THE "JOHNSON CAP." (FIG. 4).

First round. A 6-in. Vickers armour-piercing shot, without cap, and weighing 100 lbs., was discharged against the above target from a 6-in. gun (Mark B), loaded with 12·5 lbs. of cordite, at a distance of 1,000 yards. It was observed that the projectile was broken up, the point remaining fused in the plate. The extent of injury by scaling was 24 in. H × 22 in. V. No cracks were formed by the impact, but signs of a bulge were discernible at the back of the plate. The muzzle velocity was 2,034 foot-seconds, striking velocity 1,995 foot-seconds, and the striking energy 2,766 foot-tons.

Second round.—The next attempt was very successful. A 7·5-in. armour-piercing shell, fitted with the "Johnson cap," and weighing 205 lbs., discharged at 1,000 yards from a 7·5-in. gun (50 cals.), loaded with a charge of 35·31 lbs. of cordite, not only completely perforated the plate and backing, but the point of the shell, weighing 92 lbs., penetrated 20 feet into a sand bank at the rear of the target. No fragments of the projectile, except the base plug were found, and the size of the hole in the plate measured 8·75 in. × 8·5 in. Scaling had taken place around the aperture to the extent of 14·5 in. H. × 14·5 in. V. The muzzle velocity was 2,221 foot-seconds, striking velocity 2,186 foot-seconds, and the striking energy 6,795 foot-tons.

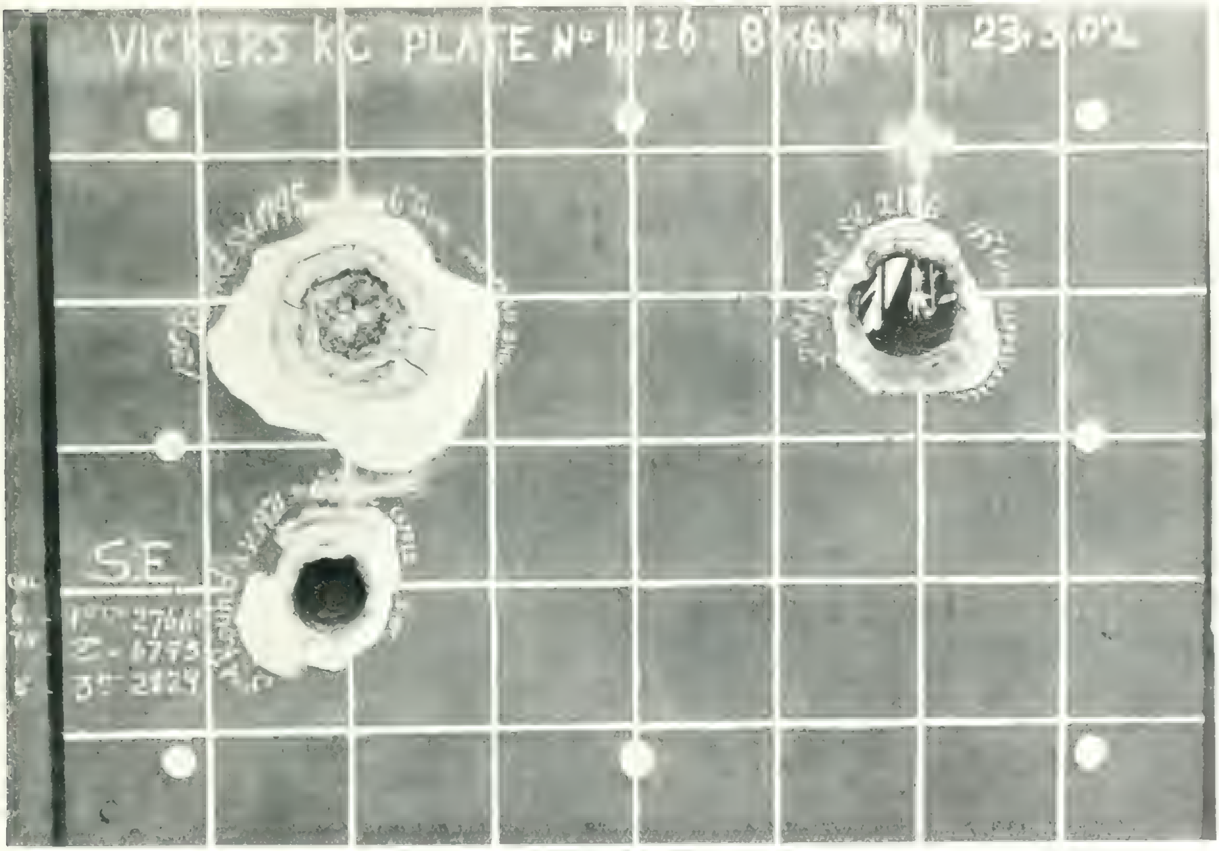
The Gun *v.* the Armour Plate.

[illegible] beyond. A trial of a 6-in. Carnegie plate gave analogous results, and a capped projectile of 100 lbs., with 1,913 foot-seconds striking velocity, was found just equal to an uncapped one with 2,290 foot-seconds, and it increased the penetrating power by 25 per cent.

The following table shows the results with an 11-in. Krupp plate, manufactured by the Bethlehem Steel Company, representing turret-armour of the battleship *Maine*, which took place at Indian Head in May. They were not so conclusive in regard to the value of the capped shot.

[illegible]	[illegible]	[illegible]	Striking [illegible]	[illegible]
in.	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	47
10	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	867	[illegible]	[illegible]	[illegible]

In the first three rounds with ordinary projectiles the plate was bulged, but not cracked. The other rounds were with capped projectiles — 1 Midvale, 1 Wheeler, and 1 Carpenter —



FIRST ROUND. [illegible]

THIRD ROUND.

SECOND ROUND.

[illegible] AFTER THE THIRD ROUND AGAINST A 6-IN. [illegible]
THE ADVANTAGE OF THE [illegible]

[illegible] 12·94 lbs. of cordite, completely perforated the plate and backing, as in the case of the heavier projectile. The shot, [illegible] 6·5 in., the extent of injury by scaling being 13 in. H × 14 in. V. The mean muzzle velocity was 2,007 foot-seconds, the striking velocity 1,071 foot-seconds, and the striking energy 2,820 foot-tons.

the first of these rounds being at about 15½ deg. from the normal, and somewhat more in the case of the succeeding rounds.

An attempt has now been made to show the varying conditions which have affected the contest between the gun and the plate, giving the superiority first to the one and then to the other. It has been shown that the Krupp process has enabled the plate to triumph, but that the introduction of the cap, which is now sure to be adopted, may again shift the balance and make the contest more equal. It remains to be seen what further advance may yet be made to meet the reinforced attack.

It must be remembered, however, that the introduction of a cap is not solely a matter concerning velocity and energy. The value of a gun rests even more in its ability to direct a projectile to the point desired, and anything that changes the conditions of its external ballistics requires to be considered from another point of view entirely. It has been pointed out that the use of the cap is likely to reduce the stability of the projectile in its flight, greatly to diminish precision of fire, and to overthrow entirely existing tables of fire. In view of these considerations, the late Admiral Sampson, then a captain, an officer of great competence in ordnance matters, is said to have pronounced against the use of the cap except in special conditions. Remembering also the fact that capped projectiles are more uncertain in result as the striking angle is increased, being affected in greater degree in this regard than ordinary shot, it may be concluded that the long contest between the gun and the armour-plate will not soon be decided by the temporary victory of either of the adversaries.

How far it is from settlement may be seen by the rival claims now put forward in the United States. Ordnance and artillery officers of the Army have devised a new fuse which they declare will not detonate until after the shell has entered far into an armour plate, and it is suggested that, with the tremendous velocities now attained, and the great advances made with smokeless powder, further progress in the manufacture of plates becomes necessary. The Naval authorities recently tried an armour-piercing shell at Indian Head, for which it is claimed that it will perforate armour of a thickness equal to its own calibre, carrying a heavy charge of high explosive. A 6-in. shell is, indeed, said to have passed through a 6-in. plate, breaking up on the other side. It seems desirable, however, to receive reports of armour-piercing high explosive shells with some caution, until extended trials have demonstrated their effectiveness. Meanwhile, Lieut. Cleland Davis, U.S.N., attached to the Bureau of Ordnance, has introduced an electrical carbon treatment for armour plates, which is said to have results much superior to anything yet known. It is stated that heavy currents of electricity are directed on the plate, while it is in a heated state, by large carbon anodes. The electric current forms an arc, carrying with it a portion of the carbon of the anode to a depth regulated by the length of the application, thus rendering the plate exceedingly hard. Admiral O'Neil is believed to attach much importance to the invention, but further information regarding it is much to be desired. The process appears to give new promise to the plate. It is, at the same time, worthy of note that Lieut. Davis has himself introduced a new form of explosive shell designed to increase the capacity for a bursting charge, and to add to the perforating power by concentrating the weight in the line of attack—in other words, to strengthen the walls of the shell in order to resist fracture.

THE DEVELOPMENT OF "WIRELESS" TELEGRAPHY.

BY

H. C. MARILLIER.

II.

MARCONI'S SYSTEM.

IN the annals of "Wireless" Telegraphy the year 1896 is memorable for the arrival on the scene of Mr. Marconi, a young Italian, who came to this country armed with a patent which he had provisionally applied for, and with an apparatus which he had been testing for a year previously near Bologna. The British Post Office, represented by Mr. (now Sir) William Preece, and the Royal Engineers, were conducting experiments on Salisbury Plain, and Mr. Marconi had no difficulty in obtaining an invitation to exhibit his system. Signals were exchanged across a valley one and a-half miles wide, and the results were promising enough to warrant more extended trials, which were carried out under the auspices of the Post Office at Penarth and elsewhere. Mr. Marconi at this date was using a very simple apparatus, based upon the elements generally employed in Hertzian experiments; and his own contributions to it appear to have consisted mainly in earthing one pole each of the transmitter and coherer, introducing choking coils into the receiving circuit, and laying down a hypothetical law of squares as representing the relation between the height at which he placed his "capacities"—cubes of metal, probably biscuit boxes in the first instance—and the space over which signals could be detected.

Lafayette, London.

GUGLIELMO MARCONI.

Mr. Marconi, however, possessed a quality of energy which was worth more than his original apparatus, and owing to this, and the favourable circumstances which have enabled him to carry out costly experiments on a large scale, he has gone on adding continual and real improvements to the system, and has succeeded in monopolising to a large extent its commercial possibilities. Indeed, on the practical side, he has had no rival so far but Professor Slaby, in Germany, whose work will be dealt with later, and in point of record accomplishment he has left Professor Slaby, as well as others, far behind. The public has a weakness for records, and Mr. Marconi's work has thus attracted an overwhelming share of popular attention. This in its turn has produced counter-attentions of an opposite character, and has led Mr. Marconi into controversial discussions as to the originality of his system and the value of what he has done. With regard to the latter, let it be admitted that he has taken a leading part in bringing "wireless" telegraphy into practical use. He has foreseen and forestalled its most useful applications. With apparently unlimited resourcefulness, working from short, up to gradually longer distances, he has erected station after station in remote and often uncongenial localities. He has spent weeks at a time at sea testing and improving the details of his receiving instruments. He has tried every known kind of apparatus, modifying it to suit his own needs, and has introduced methods of working that were unknown. In fine, nothing has damped his pertinacity or self-confidence, and these qualities, though scarcely of an ingratiating kind, do not fail to appeal to Anglo-Saxons, who never withhold tribute from the man who succeeds.

MARCONI'S CLAIMS TO ORIGINALITY.

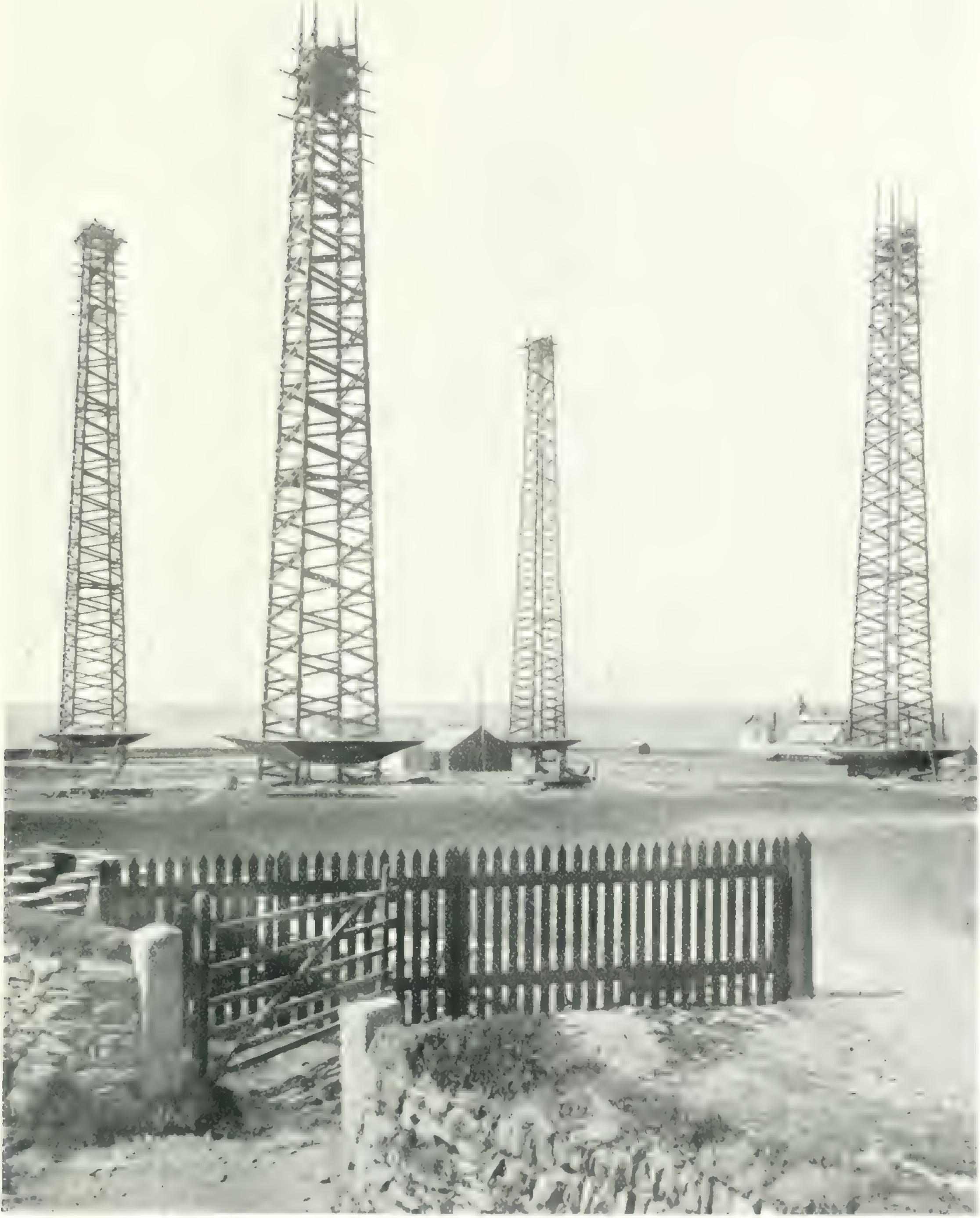
On the other hand, it is easy to overrate the originality of (at any rate) Marconi's earliest work, on which he stepped into fame, and gushing writers for the press have habitually done so, with the result that certain men of science have been driven into an opposite camp, and have accused Mr. Marconi of suppressing in his papers the credit due to others. His first patent, already mentioned, lends some colour to their view. Under the comprehensive title of "my invention" it sets forth a number of things which were pretty well known before, and were certainly not invented by Mr. Marconi. Its claims embrace, for instance, Righi's oscillator, Lodge's "antennæ," Lodge's tapper worked by a relay, Branly's and Lodge's coherers, Righi's detector for fixing the proper length of the "antennæ," Hertz's parabolic reflector, and other similar devices. It does not claim the long vertical wires which were really the secret of Marconi's success, possibly because Edison had previously used and patented the same idea.

HIS FIRST APPARATUS.

In the *Strand Magazine* for March, 1897, there is an illustrated interview with Mr. Marconi (an unusually fulsome production), which, at all events, contains one item of interest. This is a portrait of the inventor seated before his early apparatus. On one side is what appears to be an ordinary Righi oscillator, on the other a box containing the coherer and battery, with horizontal "antennæ," or copper strips, such as Lodge first used for tuning and strengthening the coherer circuit. On top of the box is a telegraphic instrument worked by the relay inside. There is no element of novelty in this apparatus, and on the face of it no special modifications. One may fairly suppose that Mr. Marconi, either from inexperience in drafting a patent, or from the difficulty of describing his arrangements without specifying all the apparatus used, was led to include much that he had found ready to his hand when he began working at the subject. Having cleared the ground on this point, we can leave Marconi's first patent, which contains very little that is now of value, and trace the course of his subsequent

MODIFICATIONS AND IMPROVEMENTS.

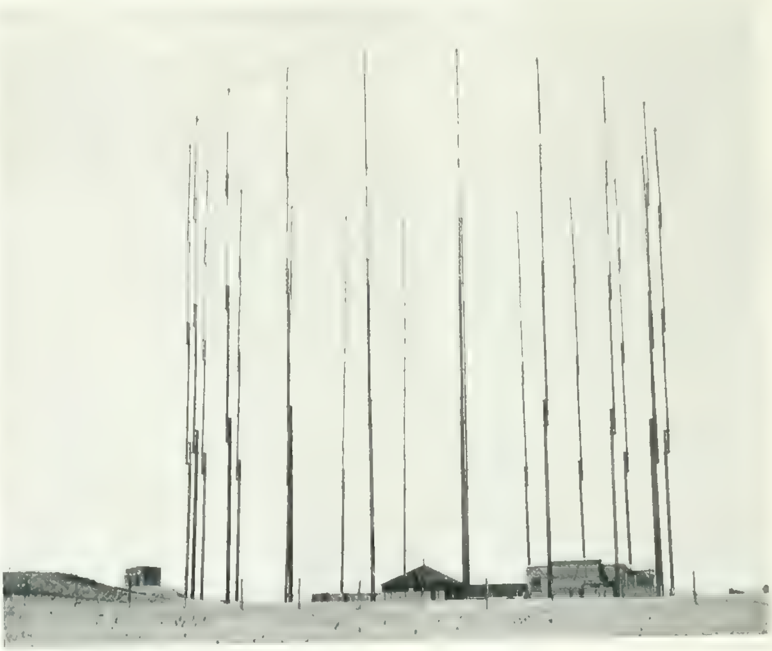
In 1898, Mr. Marconi broke off from the Post Office, and joined a company formed to exploit his system. He began by erecting a station at the Needles, Alum Bay, in which "capacities," parabolic reflectors, etc., were more or less discarded, and in which the principal feature was a long insulated wire, suspended from a mast. This was connected at the lower end to one of the ball terminals of a 10-in. induction coil, worked by a battery of 100 cells, partly in parallel, the other terminal of the coil being connected to earth. A press-down key enabled the circuit to be made and broken for longer or shorter intervals. Signals were sent to a receiving instrument on a small steamer out at sea, the vertical wire being in this case used as a collector. As soon as results warranted it, a corresponding station was erected at Bourne-



MARCONI STATION AT POLDHU, CORNWALL.

MARCONI INSTALLATION AT MAHUKONA, HAWAII.

mouth, 14 miles distant across the Solent, and later at Poole, 4 miles further still. The receiving apparatus was that already mentioned, consisting of the vertical wire (or "aerial") connected to one terminal of a metal-filings coherer, the other terminal being connected to earth. Arranged in shunt across the coherer was a circuit containing a single cell and a relay instrument, which actuated a second system, in which was a stronger battery and a Morse recorder. The relay also worked the tapper, which was an electric bell vibrating against the coherer. Choking coils and condensers were included at various parts of the circuit. The receiving apparatus was securely enclosed in a metal box (such as Branly had found necessary) to protect it from the adjacent transmitting apparatus, and only became effective when the vertical wire was switched on to it, thus enabling Hertzian waves to penetrate the screen. With the "aerial" connected at one station to the transmitter and at the other to the receiver, signals were sent from the former by depressing the key so as to form Morse code letters. The surgings set up in the wire were communicated as waves to the ether, and spread out in every direction like concentric ripples at the speed of light. When these cut the vertical wire of the receiving station, corresponding surgings (but faint in proportion to the distance) were set up in that. These were communicated to the coherer, with the result that it became a partial conductor, allowing sufficient current to pass from the single cell to operate the relay, which in turn operated the Morse inker. At the same time the tapper was set in motion, so as to "decohere" the coherer and render it sensitive once more. The action between coherer and tapper being very rapid, it hardly affects the heavy working of the Morse instrument, which there-



MARCONI STATION AT CAPE COD BEFORE IT WAS WRECKED.

fore registers true dots and dashes corresponding to the working of the key at the transmitting station. Mr. Marconi described this system fully in a paper read before the Institution of Electrical Engineers in March, 1899, and recorded the work achieved with it, which included reporting the yacht races in Kingstown Harbour from a steamer, in 1898, and establishing communication between Osborne House and the Royal yacht *Osborne* during the cruise of H.R.H. the Prince of Wales, at the time that he was suffering from a fractured patella.

MARCONI INSTRUMENT ROOM ON BOARD S.S. "MINNETONKA."

TUNING THE CIRCUITS.

The chief defect in the system at this time, and it was a serious one, was the absence of any device for tuning or screening the circuits, and Marconi's subsequent patents and experiments were mainly devoted to this necessary end. His first arrangement, patented June 1st, 1898, was the device known in Marconi language as the "jigger." The vertical wire was no longer insulated, but connected to earth direct through the primary of an induction coil. The coherer, with a condenser in the circuit, was placed across the terminals of the secondary. Coil and condenser were constructed so as to be "in tune or symphony" with the particular oscillations given off by the transmitter. In a discourse delivered at the Royal Institution, November, 1900, Mr. Marconi, curiously enough, says nothing about this use of the transformer, but confines himself to its power of reinforcing the faint oscillations received, and so extending the range of signals. He says :—

> The object of this transformer is to increase the E.M.F. [illegible] and therefore [illegible] oscillation, and so be affected at a much greater distance [illegible] some of these induction coils have been remarkable. During the naval manœuvres I had an opportunity of [illegible] with a given amount of energy and height. When [illegible] I ascertained that when the induction coil was omitted from the receiver the limit distance obtainable was seven miles, but with an induction coil similar to that shown, a distance of over sixty miles could be obtained with certainty.

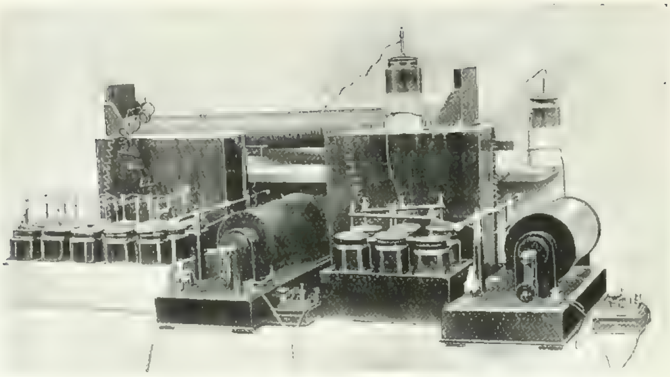


FIG. 1. MARCONI TRANSMITTER, WITH DOUBLE SYNTONISING COIL.

In the interesting series of experiments carried out between South Foreland and Wimereux, near Boulogne, in 1899, this device was constantly employed. A permanent installation had been fitted up at the same time between the South Foreland Station and one of the lightships on the Goodwins, and Mr. Marconi was understood at the time to claim that signals from the lightship did not clash with or confuse the signals from Wimereux.

PROBLEMS IN SYNTONIC EFFECTS.

The *selective* properties of the "jigger" were set forth in a subsequent paper of May 15th, 1901, read before the Society of Arts, and entitled "Syntonic Wireless Telegraphy." In this paper various methods of tuning the circuits at the different stations were described, beginning with the one referred to. Mr. Marconi described it as "the introduction of a proper form of oscillation transformer in conjunction with a condenser so as to form a resonator tuned to respond best to waves given out by a given length of aerial wire." He then went on to explain that a vertical wire pure and simple is a bad form of radiator for syntonic effects. A vertical wire discharges all its energy in one or two violent oscillations, whereas what is required is a persistent radiator, one which will give a more prolonged series of timed oscillations, the effect of which on a distant resonator will be cumulative, like the timed pulls on a heavy bell. A violent and quick radiator may affect all sorts of receivers, however tuned; but a persistent and less violent radiator will only affect the particular receiver which is tuned to it, because the oscillations given out are too feeble individually to affect others. Mr. Marconi offers two main solutions of this problem. The first is to use "an ordinary vertical radiator placed near an earthed conductor, the effect of which is to increase the capacity of the radiating wire without increasing its radiative power." By making the two conductors unequal in length a difference in phase of the oscillations was obtained, "otherwise their mutual effect would be to neutralise one another." The second solution was considered at the time more important. In it the radiating and resonating conductors take a cylindrical form, the earthed cylinder being one inside the other. The large capacity of the receiver, it is claimed, causes it to be a resonator possessing a decided period of its own, so that it is no longer apt to respond to frequencies which differ from its own period of electrical oscillation, nor to be interfered with by the stray ether waves which in summer especially render "wireless" telegraphy uncertain. Cylinders 7 metres high and $1\frac{1}{2}$ metres in diameter, made of zinc, were used, and are stated to have worked successfully and without interruption from neighbouring stations between Poole and St. Catherine's Bay, Isle of Wight.

Mr. Marconi claims in his paper that this arrangement is protected by his patent of March 21st, 1900, No. 5,387, but reference to this patent shows that it is for a concentric cable, or pair of vertical conductors, which should in any case be of considerable length, and the tuning is effected by the use of inductance coils. At the transmitting station a coil of variable inductance is used in circuit with one of the conductors, and at each receiving station a similar coil, but of fixed inductance, in circuit between the coherer and one of the conductors. The inductance of the coil at the transmitting station is varied so as to be in tune with any desired receiving station.

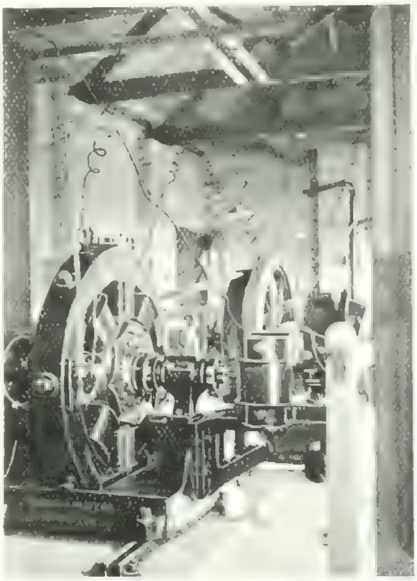
This is similar, though by no means identical, with a further system described in the Society of Arts paper, and claimed as patented April 26th, 1900, in which a single vertical wire is used, and the tuning is effected by a closed condenser circuit, such as was devised by Sir Oliver Lodge in his syntonic Leyden jar experiments. The transmitter consists of a variable condenser in circuit with a Tesla coil or transformer, and the vertical wire is made to correspond with this in period by adding or taking away length. In the receiver, the vertical conductor is connected to earth through the primary of an induction coil as before, and the coherer completes the secondary circuit, but has an adjustable condenser shunted across its terminals. In order to get the best results, the period of oscillation of the vertical wire, transformer primary, and earth connection should be in resonance with the secondary circuit which includes the condenser. The condenser "increases the capacity of the secondary resonating circuit of the transformer, and in the case of a large series of feeble, but properly timed oscillations being received, the same is summed up until the E.M.F. at the terminals and the coherer is sufficient to break down its insulation."

SIMULTANEOUS MESSAGES.

With this system Mr. Marconi claims to be able to transmit multiple messages from one vertical wire, by means of differently tuned circuits, each of which will communicate with one particular receiving station similarly tuned, and with no other. Professor Fleming vouches for the accuracy of this claim, but I am not aware of the extent to which it has been tried. Fig. 1 shows a duplicate transmitting apparatus in which selective tuning is got by dividing the long coil shown into two unequal parts, corresponding with the receiving apparatus at two different stations. This apparatus has been demonstrated to various Government officials; but, so far as I know, it is not yet in permanent use. Syntonic apparatus on the principle just described is, however, commonly installed by the Marconi Company now, and syntonic messages have been successfully exchanged with an American liner up to a considerable distance, the same being imperceptible to a second liner following in the wake of the first.

TRANSATLANTIC COMMUNICATION.

Mr. Marconi's most recent work has been in the direction of establishing Transatlantic communication, and his results have been so widely published that there is no need to dilate on them here. The apparatus used in these experiments has not been described, but it is known to differ very considerably from anything Mr. Marconi has used before, and the small photograph of the interior of the Poldhu station in Cornwall, which Mr. Marconi has built for these experiments, shows that an alternator of very considerable size is required. This, if report speaks accurately, generates a continuous high-tension Tesla discharge, which is interrupted by means of a magnetic, or more probably a mechanical, blower. The radiator consisted, in the first instance, of 50 naked wire conductors suspended from a horizontal wire rope joining the top of two masts, each 48 metres high, and converging to a common centre. A corresponding station at Cape Cod, Mass., U.S.A., had the conductors suspended from a circular ring joining the tops of a great circle of masts (see illustration), but both stations were unfortunately wrecked by a storm within a short time of each other. A new station is being erected at Poldhu, with four towers of scantling arranged in a square (see illustration), to carry the vertical radiators, which will hang from wires joining the tops of the towers and will meet at a common centre. Similar stations are also being put up in America and in Canada, the Government of



ALTERNATOR, POLDHU STATION.

which has subsidised the experiment to the extent of £16,000.

The signals received across the Atlantic by Mr. Marconi (the letter "S" repeated) were transmitted from Poldhu to a temporary station in Newfoundland, where the vertical wires were suspended from a balloon or kite. The constantly changing capacity of this conductor made the ordinary Marconi system unworkable, and the signals were received on a telephone by means of a mercury coherer, invented by a signalman in the Italian navy named Castelli. There has been a good deal of discussion in the technical press over the merits of this invention and over certain rival claims to it; and Mr. Marconi has been extensively attacked for not mentioning the apparatus in reporting his experiments, as well as for (apparently) patenting it first in his own and then in a rival claimant's name. The mercury coherer, consisting of a globule of mercury between an iron and a carbon plug, possesses a far higher degree of sensitiveness than the ordinary metal filings coherer, and is self-recovering. Mercury for this purpose has been proposed long ago, both by Professor Chunder Bose, of Calcutta, whose advanced and early researches call for further mention hereafter, and also by Mr. Appleyard; but this is the first time it has been practically applied.

MARCONI'S NEW RECEIVER.

Since the episode above referred to, Mr. Marconi has brought out a newer, and, it is claimed, still more sensitive, receiver, based upon the known fact that electric waves will magnetise and demagnetise a steel needle. The apparatus was fully described in a paper read before the Royal Society, June 12th, 1902. Its construction is as follows:—

> On a core consisting of thin iron wires are wound one or two layers of fine insulated copper wire. Over this winding insulating material is placed, and over this again another longer winding of thin copper wire. The ends of the winding nearest the iron core are connected to the plates or wires of the resonator, or, as is the usual practice in Marconi long-distance telegraphy, to earth and to an elevated conductor; or they may be connected to the secondary of a suitable receiving transformer or intensifying coil, such as are employed for syntonic wireless telegraphy. The ends of the other winding are connected to the terminals of a telephone or other receiving instrument. Near the ends of the core is placed a magnet, revolved by a clockwork arrangement, so as to cause a slow and constant change, or successive reversals, in the magnetisation of the iron core. If electrical oscillations of suitable period be sent from a transmitter, rapid changes are effected in the magnetisation of the iron wires, and these changes cause induced currents in the windings, which in turn reproduce on the telephone the signals sent from the transmitting station. Should the magnet be taken away, or its movement stopped, the receiver ceases to be perceptibly affected by the electric waves.

The phenomenon exhibited by this apparatus appears to be a change in "lag" or magnetic hysteresis caused by the incidence of the waves on a body subjected to a varying magnetic field. The rapid alterations of molecular strain can be detected by a telephone. Mr. Marconi claims for his new receiver that it possesses a practically uniform and constant resistance much lower than that of a coherer in its sensitive condition, also that it will work with a much lower E.M.F. Its usefulness, however, has still to be tested.

Mr. Marconi's system has had the advantage of extensive trials in the navies both of Great Britain and Italy and in the mercantile marine. One of our illustrations shows the arrangement of the apparatus on board S.S. *Minnetonka*, the latest vessel to be so fitted up. Another illustration shows one of the masts erected in the Hawaiian group of islands by a private company for inter-insular communication. The venture has, for some reason, broken down, but there is some talk of restoring it. Marconi apparatus was also tried in the South African War without great success, owing, as Mr. Marconi himself says, to want of masts and proper conditions of working. The system (speaking of "wireless" telegraphy in general) certainly seems more adapted for sea than for land communication,* and is likely to come into common use on ships. It is already installed at many of the Lloyds' calling stations, the Marconi Company having succeeded in getting a fourteen years' monopoly from the Corporation of Lloyds.

In the next article we shall deal with a number of inventors whose work has not yet attained the range or the prominence of Marconi's, but who have, nevertheless, contributed to the development of "wireless" telegraphy, and who may presently come forward as rivals in the field.

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* The Orling-Armstrong and other earth-current systems are, of course, an exception to this rule.

THE LARGEST SUSPENSION BRIDGE IN THE WORLD AS IT WILL APPEAR WHEN COMPLETED.

THE WORLD'S GREATEST SUSPENSION BRIDGE.

By

W. B. NORTHROP.

BETWEEN New York and Brooklyn cities there is now being built the largest highway suspension structure in the world. Already the making of the great suspension cables has begun, and the work is progressing at a rate which assures the completion of the bridge in about two years.

This bridge will cost, for the structure alone, about £1,600,000, and including the money which must be paid out for the right of way over certain city property, £2,700,000.

Compared with some of the present big bridges of the world, the New East River Bridge takes easy precedence. The centre span is 1,600 ft., 5 ft. longer than the Brooklyn Bridge, 320 ft. longer than the famous bridge at Clinton, Canada, and 780 ft. longer than the suspension bridge over Niagara River, near the Falls. On completion it will connect one of the most densely populated districts of New York city with one of the largest thoroughfares of Brooklyn. The bridge will span the East River between Delancy Street, New York, and South Sixth Street, Brooklyn. Delancy Street is very near Grand Street, on the New York side, while South Sixth Street is but one block north of Broadway, Brooklyn.

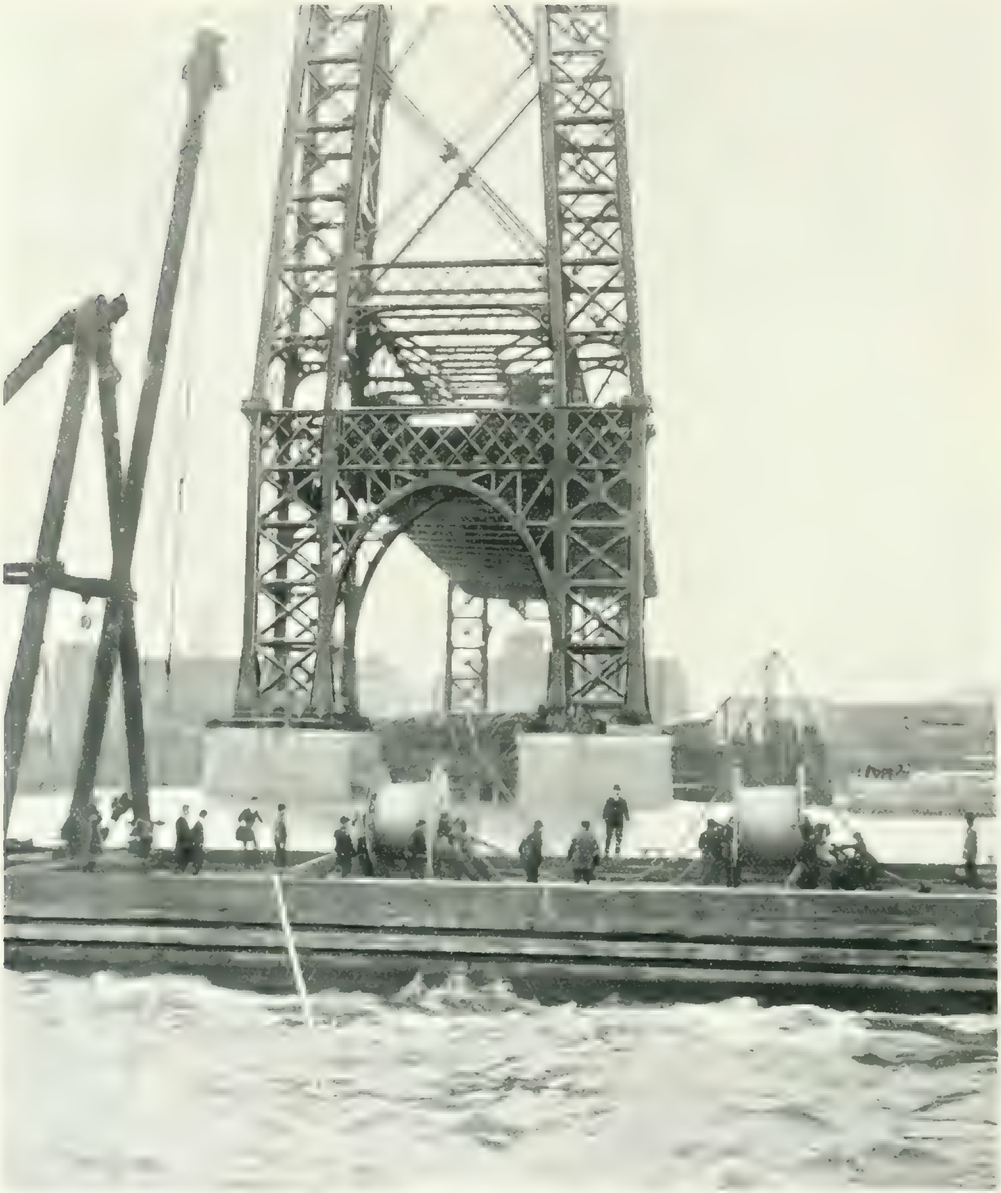
The total length of the new bridge, including spans and approaches, will be 7,200 ft., the approaches on both sides being about 1,200 ft. longer than those of the present Brooklyn Bridge.

Between the Brooklyn Bridge and the New East River Bridge will exist a strong family resemblance. The towers of the former, however, are composed of stone, while those of the latter are of iron.

When it was first proposed to throw a span of iron across the East River, in 1870, at the time of the projection of the Brooklyn Bridge, the plan was considered by many to be utterly impracticable. Engineering authorities laughed the project to scorn, while the general public regarded it as altogether chimerical.

It was only after the Brooklyn Bridge had been subjected to years of severe straining that the public felt assurance in patronising it. Even when it was proposed, a few years ago, to run two additional lines of cars on the outer roadway, it was suggested that the bridge was not sufficiently strong to bear the weight.

To show the advancement in ideas since the building of the Brooklyn Bridge, it may be stated that not a question has been raised as to the mechanical possibilities of the present project. Everyone in America regards it as a matter of course, and some even imagine the new bridge will bear ten times more weight than will actually be put upon it.



STRETCHING THE FIRST CABLE FROM NEW YORK TO THE BROOKLYN TOWER.

PRELIMINARY WORK.

A great deal of preliminary work had to be done before a suitable site could be found, where the water would not be too deep, and where the bed on which the foundations were to rest would be sufficiently firm. Exactly similar points had to be chosen on both the New York and Brooklyn sides of the East River.

The first step in the construction of the new bridge was the sinking of immense caissons. The caisson is built according to the depth of water in which it must operate. On the New York side this depth was but 20 ft., the principal caisson having been 28 ft. high, 63 ft. wide, and 79 ft. long. It weighed 1,400 tons. Its sides were of 14-in. timber, the interior being of southern pine, planed and squared, and covered by an additional planking 2 in. thick, tongued and grooved together. The caisson was caulked thoroughly and tarred throughout.

Men who work in caissons under the beds of rivers are called "Sand Hogs." Each gang has two "shifts" of four hours' duration. "Sand Hogs" receive about eighteen shillings a shift for their wages. Where the depth is very great the men labour at much physical disadvantage. Their wages are, in consequence, proportionately higher. Some only remain down about ninety minutes, this securing them a day's pay.

The main danger to caisson workers comes from passing too quickly through the air locks. Of course, as one descends towards the river bed the atmospheric pressure increases. If one goes through an air lock too quickly the sudden increase or decrease of pressure will affect the lungs and heart. If the workman neglects to take proper rest after caisson work, he gets a strange malady called by the men "bend." It is a species of paralysis which often terminates fatally.

FOUNDATIONS IN DEEP WATER.

When the sand in the air chamber has been removed to a sufficient depth and the bed rock is reached, the laying of the foundation-stones of the bridge proper on the bed of the river is commenced.

Though the depth of water on the New York side was but little, that on the Brooklyn end was more than 100 ft. Some parts of the work were carried on at a depth of 105 ft.—within 15 ft. of the depth beyond which it is impossible for human beings to do this class of work. At 120 ft. below the surface there is a pressure of 57·77 lbs. per square inch, as against a normal pressure of 15 lbs. per square inch, and at this great depth it is fatal to stay for more than five minutes.

STRENGTH, MATERIALS, AND DIMENSIONS.

The new bridge will be four times as strong as Brooklyn Bridge, and yet the material in the old bridge is far more massive. The weight on

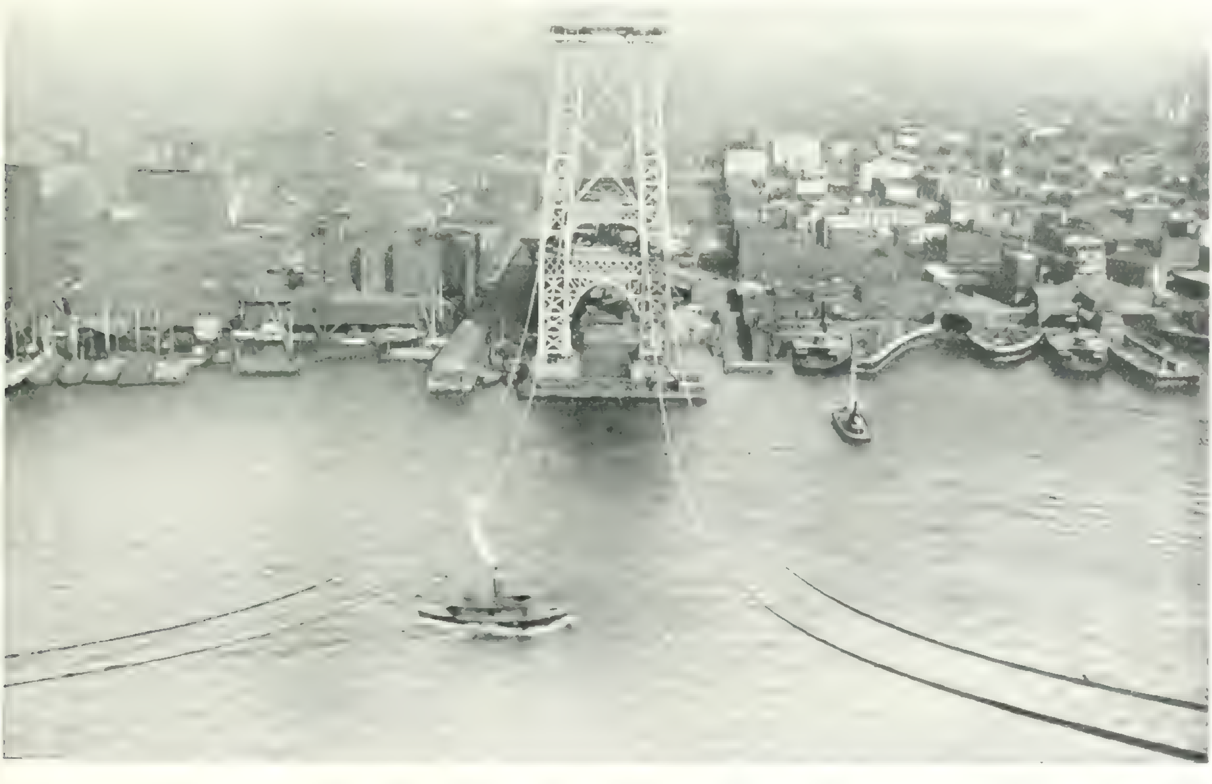
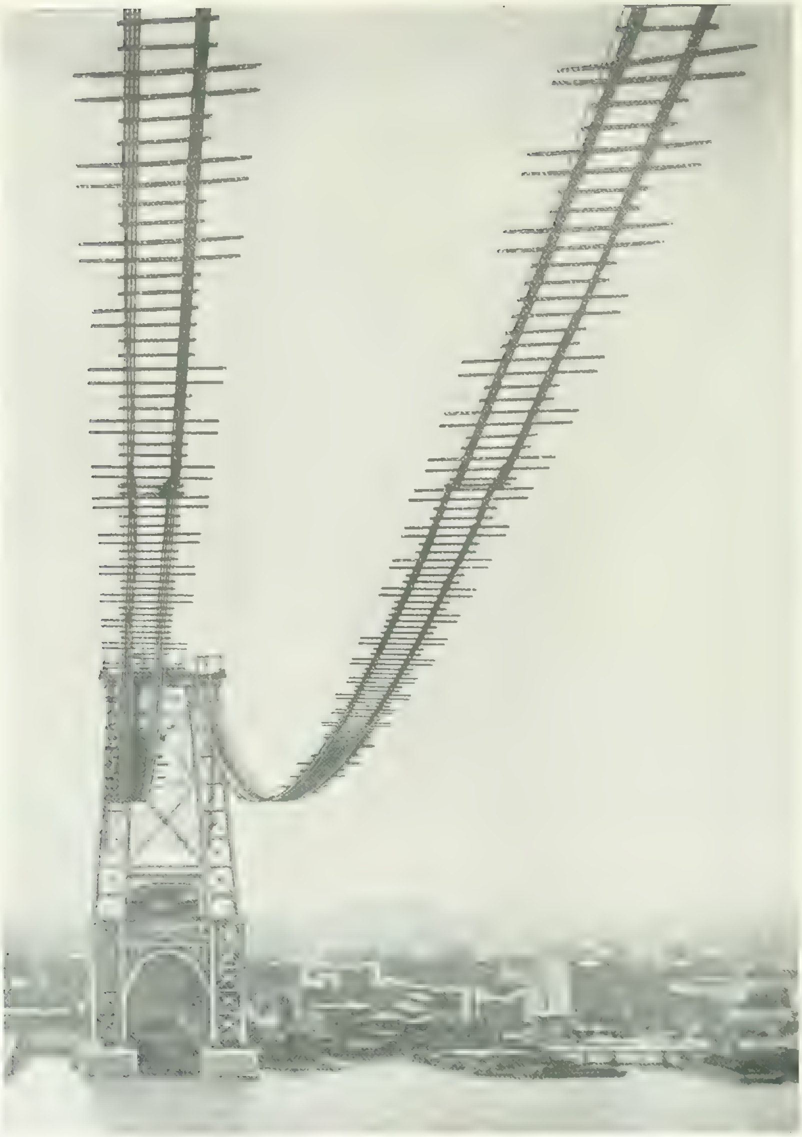


PHOTO TAKEN FROM ABOVE CABLES BEFORE [illegible] [illegible] OF FOOT-BRIDGE.



LOOKING UP AT FOOT-BRIDGE.

the tower foundations of the Brooklyn Bridge is 100,000 tons, while that on the foundations of the new bridge is but 30,000 tons. The difference is owing to the use of steel for the towers of the new bridge, as already mentioned.

The width of the bridge will be 118 ft.—33 ft. wider than Brooklyn Bridge. It will carry six railway tracks, as against four of the old bridge, and there will be two wide roadways.

The enormous gain in strength of the new bridge over the old is due to the fact that the cables of the former are to be used solely for supporting the span which depends over the river. In the Brooklyn Bridge, however, the cables support both the land spans and river spans. The shore, or land, spans of the new bridge are supported partly by the anchorage and partly by intermediate towers, placed between the anchorages and towers of the suspension portion of the bridge.

The World's Greatest Suspension Bridge.

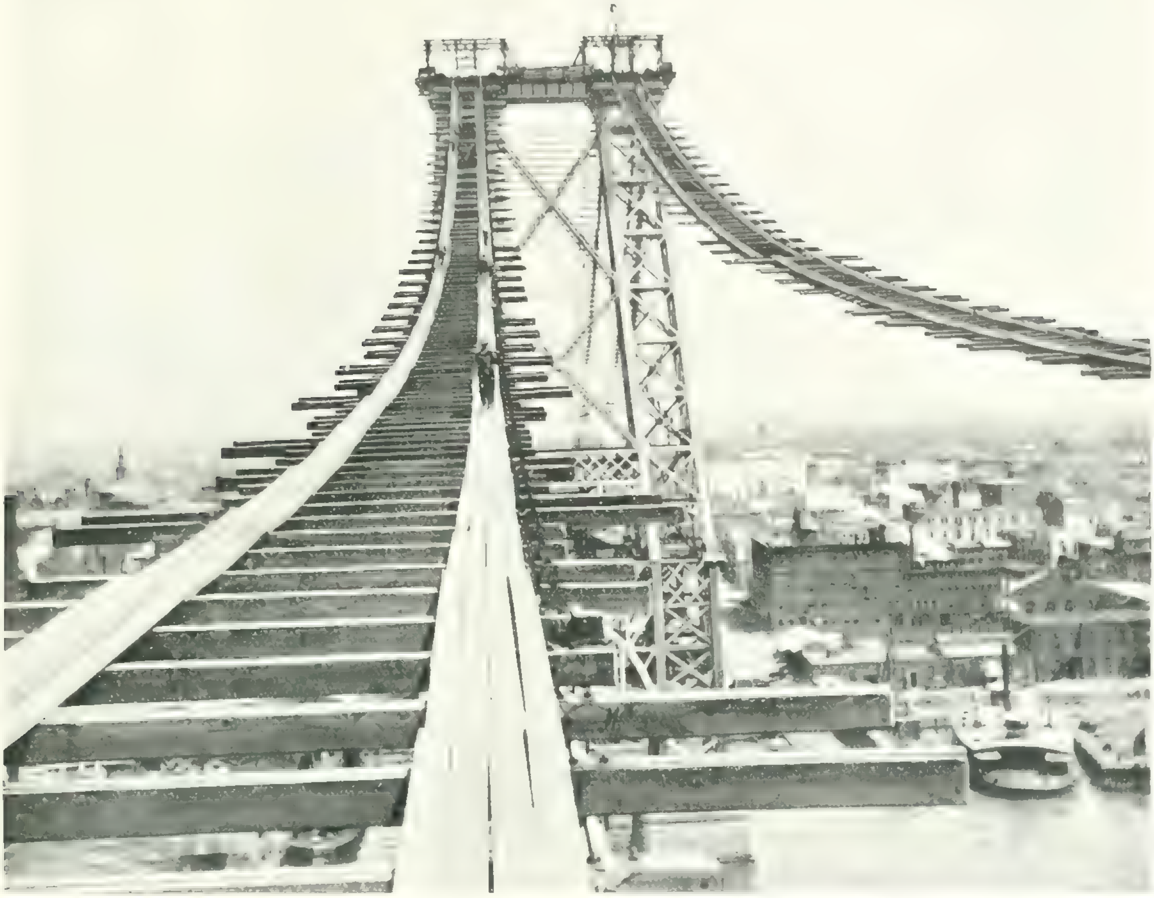


PHOTO TAKEN FROM CENTRE OF FOOT-BRIDGE, LOOKING WEST, TOWARDS BROOKLYN.

All the cables will have to do in the new bridge will be to support the 1,600-ft. span which stretches across the river at an elevation of 135 ft.—at its lowest point—above the surface of the water. This height will only be attained at the central point of the bridge, however, the whole suspension portion of the bridge forming a graceful, though gentle, arc. At the land end of the suspension on each side of the river the height will be only 117 ft.

The steel towers of the new bridge are 333 ft. high. The towers and land spans required 12,000 tons of steel in their building. Each tower, taken separately, weighs 3,000 tons.

GENERAL FEATURES.

The bridge itself will consist of four cables, with two trusses. Each cable will have 37 strands, each strand consisting of 281 wires. This will make 10,307 wires to each cable. The diameter of each cable will be 18¾ in. The wire in the bridge will have a tensile strength of 200,000 lbs. per square inch. These wires will have to bear the weight of the bridge proper, which will exert a pull of 20,000 tons on the wires. All of this weight will be borne by the anchorages on each side of the immense structure. These anchorages are made of massive blocks of stone, each anchorage containing 45,000 cubic yards of material. In the entire bridge, when completed, there will have been used 6,500,000 ft. of timber, 130,000 cubic yards of masonry, and 45,000 tons of steel. The work will necessitate excavation of 125,000 cubic yards of material, and the destruction of more than 500 buildings.

ON THE CENTRE OF THE FOOT-BRIDGE—A PERILOUS POST.

The new bridge is one-sixth longer than the Brooklyn Bridge, and its average width is 40 per cent. greater than the older structure. In its great breadth of 118 ft. it will accommodate two carriage-ways, each 20 ft. wide. In addition, there will be two lines for elevated railway trains and four tracks for surface cars, all of which will be run by electricity. Two foot-walks, each 12 ft. wide, and two bicycle paths, each 7 ft. wide, will occupy a place just above the electric surface car tracks.

Five hundred men have been kept constantly employed on the New East River Bridge almost since the day the work began. This figure refers to men actually employed in the work; not to that large additional number working in the various steel mills turning out portions of the super-structure.

Now that the foundations, supports, land spans, steel towers, and anchorages are finished, the work of the men is centred on the construction of an elaborate foot-bridge.

The foot-bridge in question has taken three months to build, and has cost about £40,000. It is only temporary; its object is to afford the men a foothold while engaged in the process technically called "cable making."

The foot-bridge consists of twelve $2\frac{1}{4}$-in. cables, arranged in four groups of three each. Each cable is about 4,000 ft. long, and stretches from the anchorage on one side of the river to that on the other.

The process of throwing even these small cables for the foot-bridge from tower to tower was by no means an easy task. There is so much traffic on the East River, New York, that the work of stretching the first set of cables had to be done with great rapidity. As a matter of fact, it was accomplished in something under twenty minutes. There were several large bets lost in New York on the day the cables were stretched, many believing the work would take at least half a day.

HOW THE FIRST CABLE WAS STRETCHED.

On the morning set for the stretching of the first cable between the towers—April 11th, 1901—a large barge was towed to the base of one of the steel towers. On this barge was a reel containing the cable. One end of the cable was hitched to a wire rope and hauled up over the steel tower. It was then passed back to the anchorage, where it was made fast. A tug-boat then pulled the barge out across the river. As the barge passed away from the tower, the reel with the cable unwound. The wire was allowed to sink to the bottom of the river. This prevented the cable from interfering with river traffic. The cable rested on the bottom of the river until the engineers were ready to haul the end of it up to the tower on the side of the river opposite to that on which the first end had been made fast.

The four cables were all hauled up in this manner. The foot-bridge subsequently built was put up through the agency of a number of travelling platforms, called "buggies," which hung down from the cables. Men on these "buggies" laid the planking of the foot-bridge. The "buggies" moved along each day as the work progressed.

When the foot-bridge is completed, the making of the cables proper begins. Guide wires are first laid between the towers, so that the workmen can tell just how much the big cable should "sag," or drop down, in the middle.

The main cables will be made up of 8,000 miles of fine wire. This wire will be wound back and forth across the river, just as a skein of thread is wound between the two hands. As has been said, the cables will be divided into strands, each strand having 281 wires, each cable having 37 strands. Each wire making up the cables is carried over the towers, resting on great saddles, one saddle being on the top of each tower. As each strand of 281 wires is made up, it is held together by temporary steel bands, put on the cables at certain distances along their entire length. On the making up of the complete cable of 10,397 wires, the temporary steel bands are removed and permanent bands are put in their place. These bands are of cast steel, and will encircle the entire cable. From them will hang down wire ropes, or "suspenders," which will hold up the floor beams of the bridge proper.

After all the bands have been put on the cable, the latter will be covered by steel shields, each shield overlapping the other in such a way as to shed water. It is noteworthy that all the wires in the four cables will form one continuous coil. Each coil will run out about 64,000 feet before it will be necessary to join another coil to it. While each strand is being made up, it will rest in a temporary saddle. When the cable is complete, it will be taken from this saddle and dropped into place. Thus, the cables will at first be somewhat higher than their final actual position.

THE ANCHORAGES.

The ends of the cables will pass into great bars called "eyebars"—each having a loop in its outer end. These eyebars are deeply embedded in the masonry, there being twenty bars to each anchorage on either side of the river.

Each eyebar is composed of steel, and the bars are arranged in sets. There will be four eyebars to every three strands.

Actual cable making on the great bridge has begun, and, as has been said, the structure will be completed in about two years. The chief engineer is Mr. L. L. Buck, who worked with Mr. Roebling on the Brooklyn Bridge and also built the famous suspension bridge across Niagara Falls. The bridge will, on completion, be a veritable triumph of twentieth-century engineering.

MILLING MACHINES

BY

JOSEPH HORNER.

This article illustrates types of geared feeds for producing [illegible]. It also treats of circular milling and vertical spindles.

IV.

THE principal recent geared feeds illustrated in this article are of special interest at the present time, because the trend is unmistakably in the direction of the substitution of these for belt feeds. But two years ago they were still retained by the leading manufacturers; now they are no longer in evidence in their practice. One cannot wholly attribute this change to mere fad or fashion, though the belt system is still retained in many good machines. It must be recognised as one result of the present demand for the heavier duty required from milling machines, in common with other tools, such as lathes, grinders, planing machines, gear cutters, etc.

In the milling machine there is one case particularly for which the powerful geared feeds are eminently suitable, namely, the feeding of heavy work vertically. The elevation of a heavy table with a massive piece of work upon it makes severe demands upon the feed, which is better met by toothed wheels than by belting, unless the latter is of good width, and taut.

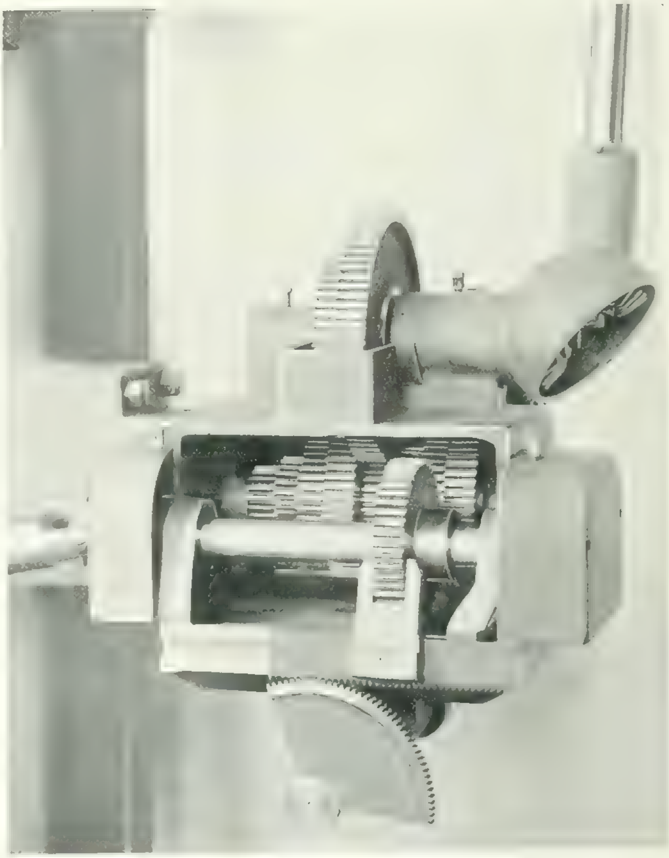


FIG. 4. REAR VIEW OF LOWER GEAR BOX OF CINCINNATI MACHINES, WITH COVER REMOVED.

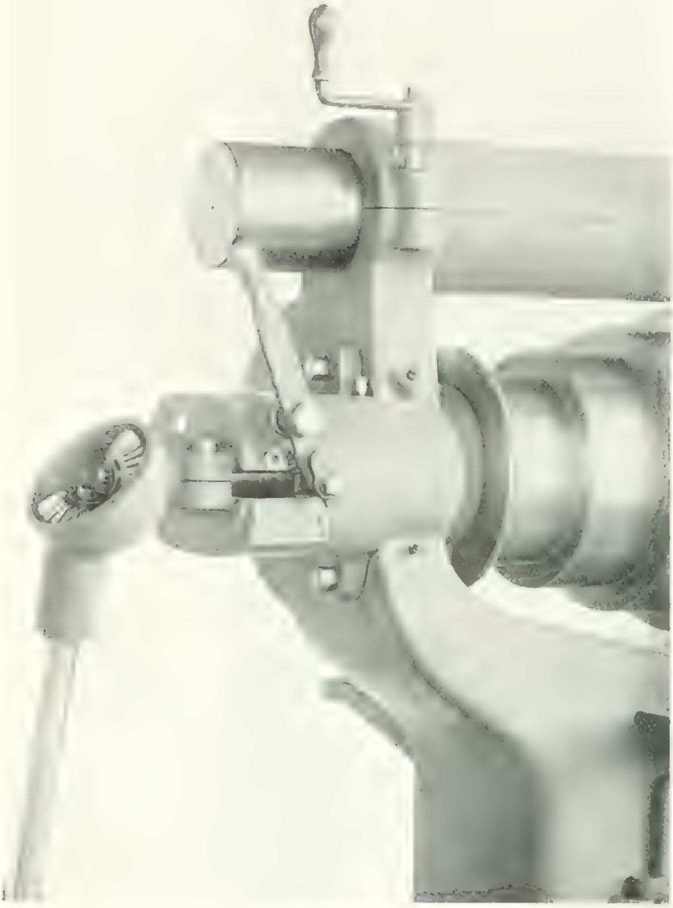


FIG. 1. UPPER GEAR BOX OF CINCINNATI MACHINES, WITH COVER REMOVED FROM MITRE GEARS.

THE FEED ARRANGEMENTS OF THE NEW CINCINNATI MACHINES.

The Cincinnati Milling Machine Company now derive the feeds from the spindle, on their back geared machines, in place of the belt cones previously used. The positive feeds can be changed by simple lever movements while the machine is running. From twelve to sixteen changes are thus obtainable on different machines. The illustrations (figs. 1 to 4) will render the method of operation apparent.

The gears are contained in two boxes; one at the rear end of the spindle (fig. 1) shown in section in fig. 2, the other below, at the rear of the column (figs. 3 and 4), the two being connected by a vertical telescopic shaft. In fig. 4 the covers by which the wheels are enclosed in the box are removed to show the internal arrangements. For every spindle speed, two speeds are imparted to this shaft by the sliding gears A, in the upper box (fig. 2), by means of the lever seen in fig. 1. Two feed gears in the lower box are thus driven in the first place. These are the upper ones in fig. 4. Each one is in permanent engagement with a wheel on one of two nests of cone spur gears—the lower wheels in the box (fig. 4) mounted loosely on their shaft, and independent of one another. The larger of the two upper gears engages with the smallest wheel on the right-hand cones, the smaller meshes with the largest wheel on the left-hand cone, so that these run at widely different rates.

The means by which varying rates are transmitted thence to the machine slides are by the intermediate sliding gear in fig. 4—the one which stands out to the front, on

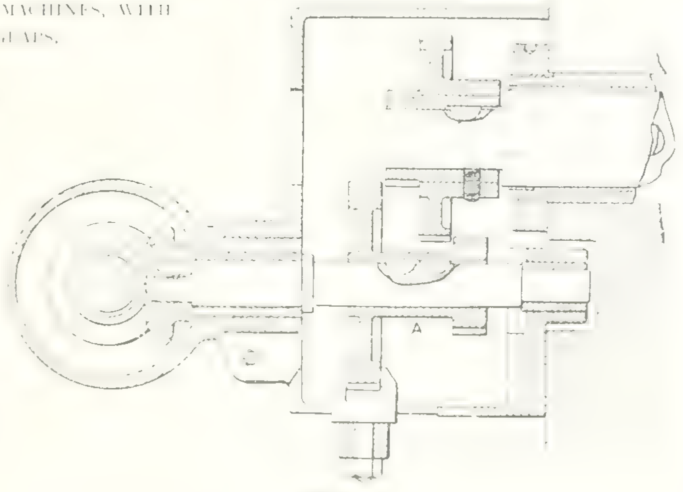


FIG. 2.

its own separate spindle. This is moved along its shaft and brought into engagement with either wheel on the series of cones. It is moved longitudinally by the rack and sector seen below. The lower lever is placed in position opposite figures marked on the quadrant (fig. 3), which indicate the rate of feed in thousandths of an inch per revolution of the spindle. The intermediate wheel is now brought into engagement by the upper lever (fig. 3), which moves the mechanism bodily. A helical groove in the hub of the lever engages a pin in the slide which carries the intermediate gear and the sector rack and lower lever. The gears are of steel, cut, and the bearings of bronze.

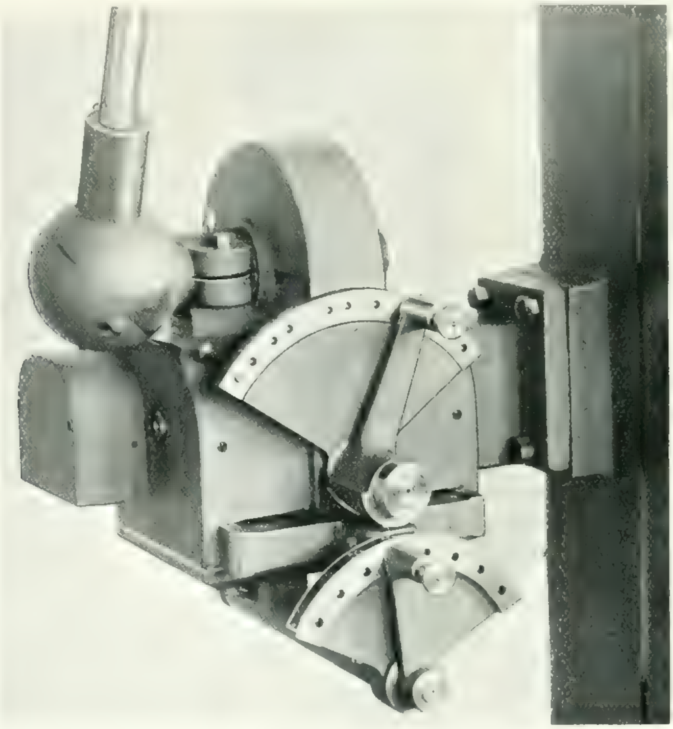


FIG. 3. EXTERNAL VIEW OF LOWER FEED BOX ON NEW CINCINNATI MACHINES.

The driving cone and back gears are so proportioned that each of the sixteen spindle speeds is correct for the most suitable surface speed for cutters of standard diameters, when working at speeds of 20, 40, and 60 ft. per minute.

THE GEAR BOX OF THE NEW BROWN AND SHARPE MACHINES.

The latest Brown and Sharpe feed is also an interesting one. One of the machines to which it is applied was illustrated in fig. 3 in the August issue, and that, with the sectional view (fig. 5) here given, and description, will render its essential features clear. In this case also the feeds are derived from the spindle speeds. Sprocket wheels and a pitch chain are used, driving from the spindle to the change gear box at the side of the pillar, A (fig. 5) being the driven sprocket. This rotates the shaft, B, on which are two wheels, C, D; C running on the shaft with a long boss, and D running on the boss of C. These are actuated by the clutches, *a* and *b*, by the movement of a lever outside the box, the range of movement of the clutch being arrested in each direction by a knob. When gear C is in operation a slow series of feeds is thrown in; with gear D, a series of quick ones. Either movement is transmitted

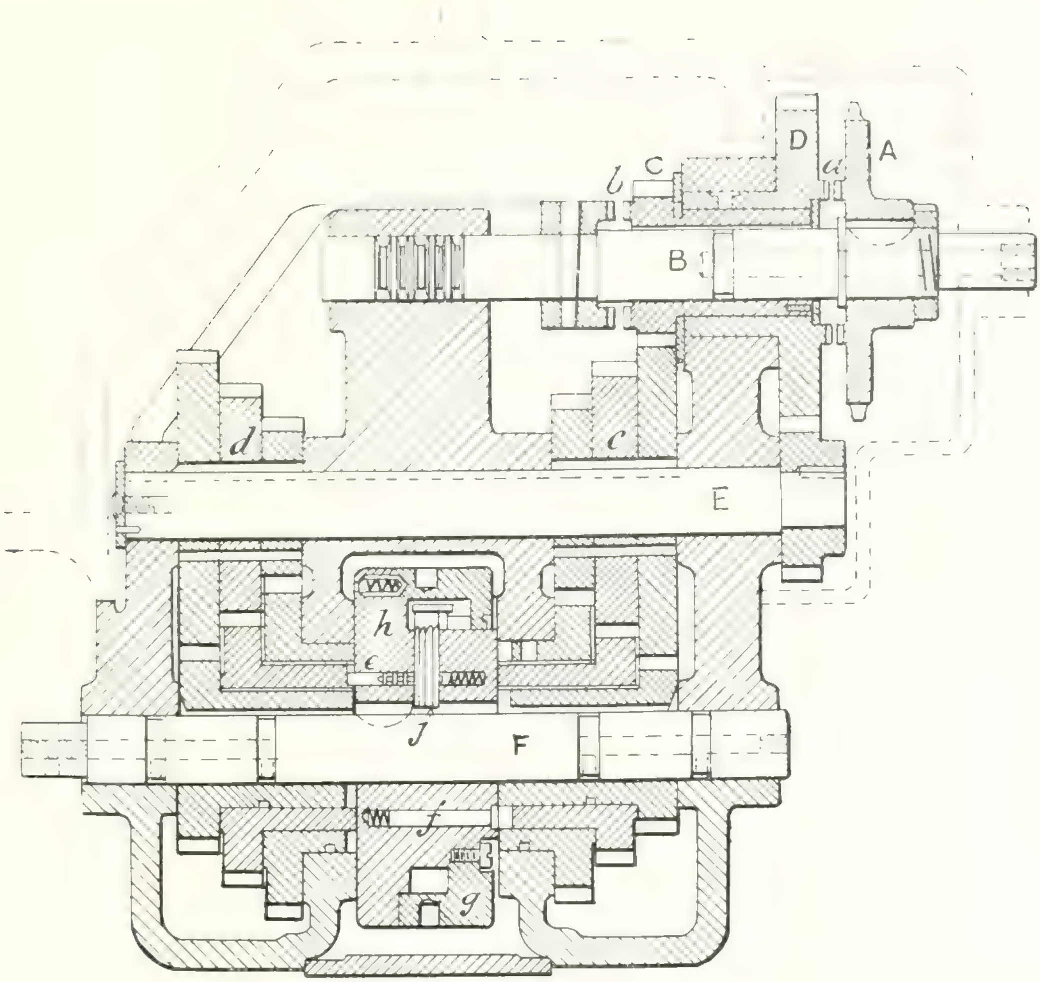


FIG. 5.

through an intermediate shaft, E, to the loose wheels on the feed shaft, E, which transmits power to the table through a telescopic shaft. The two sets of gears, *c* and *d*, are keyed upon E. The loose wheels on F have long hubs running one upon another, except those at the extreme ends, which go directly upon the shaft. These wheels are engaged by a series of six locking pins, two of which are shown at *e* and *f*, and which enter recesses in the hubs of the gears. An index disc, *g*, controls the position of these pins. It turns on the disc, *h*, and carries a cam for actuating levers that are fastened to the ends of small pinions that engage with rack teeth cut in the locking pins—details not shown in this figure. The pinion levers drop into a recess in the index disc, and, as there is but one recess, only one feed can be engaged at one time.

THE GEAR FEEDS OF THE GARVIN MACHINES.

The latest machines by the Garvin Machine Company, for whom Messrs. C. W. Burton, Griffiths and Co., of London, are the English agents, differ in several details from common types. There is no telescopic shaft, but movement is communicated to a vertical feed shaft situated within the column. The feed is chain operated, and derived from a sprocket wheel on the rear end of the spindle. Slack is taken up by moving the feed box bodily vertically, with an adjusting screw.

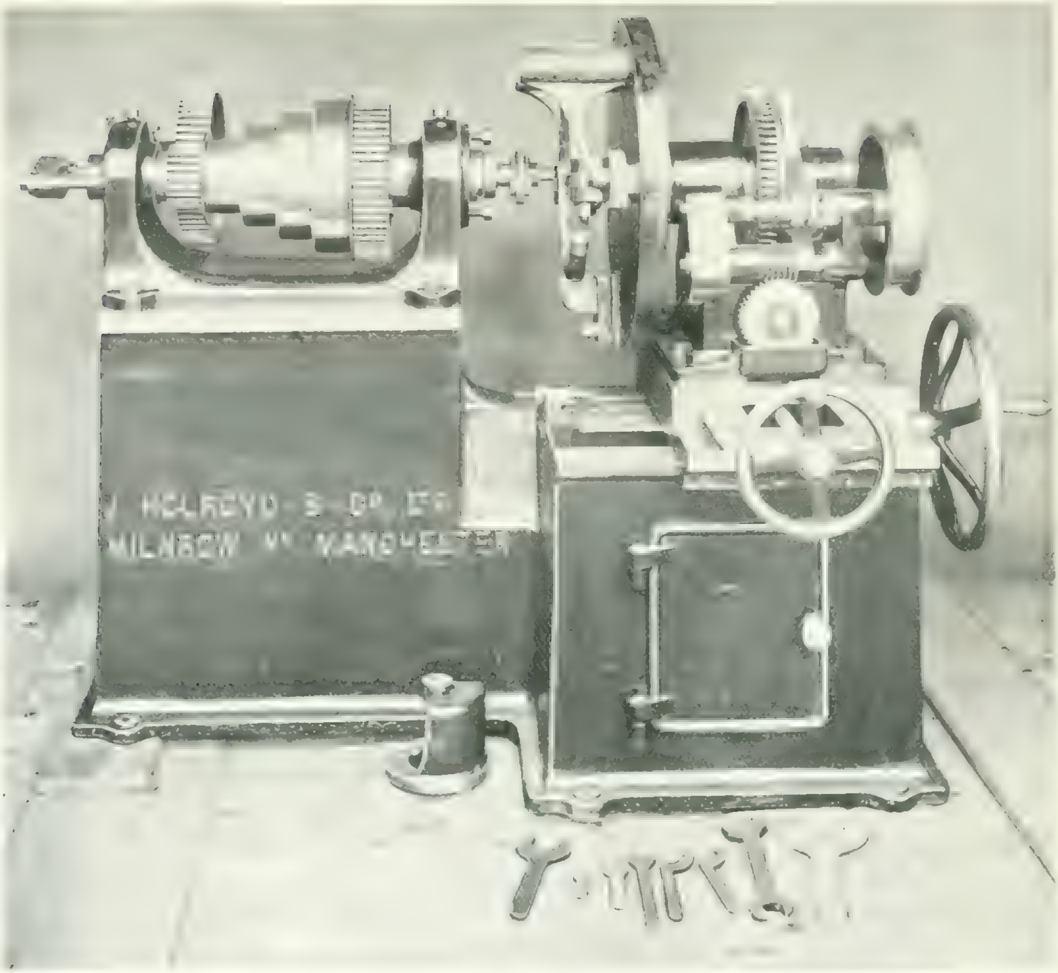


FIG. 6. CIRCULAR MILLING MACHINE.

Nine changes of feed are obtainable directly by cones of gears in the box, and nine more by transposing the wheel and pinion on the spindles at the end of the gear box. The eighteen changes thus obtained range from $\frac{1}{256}$ in. to $\frac{1}{4}$ in. for each revolution of the spindle. The change gears are hardened, and run in oil. They are put into engagement by means of index levers and spring keys, and locked by a lever in notched dial plates.

CIRCULAR MILLING. THE HOLROYD MACHINE.

Firms specialize around standard types of machines, and in some cases the additions practically constitute a new type. Thus in the machine by Messrs. John Holroyd and Co., Ltd., of Milnrow, near Rochdale (fig. 6), a horizontal miller possesses the apparent anomaly of being without vertical adjustment either to the head or the table. The reason is that an attachment is fitted on the table to perform one function only, namely, that of circular milling. This is a class of work that the lathe is being deprived of by the milling machine, and which has been performed regularly for some years past on worm wheel blanks. Its special value lies in tooling light wheel rims, and rings that would be very liable to spring if done in a lathe. This practice is sufficiently promising to induce Messrs. Holroyd, who make a speciality of milling machine manufacture, to design the tool here illustrated in figs. 6 to 9. The photo (fig. 6)

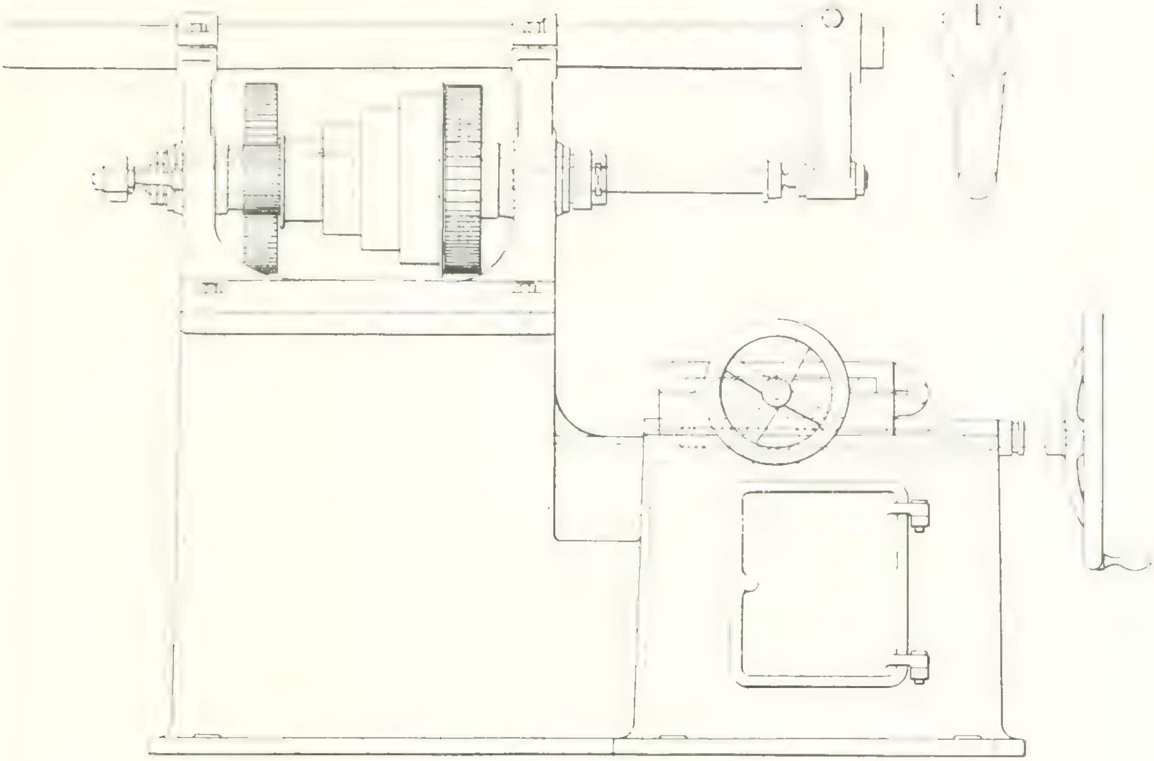


Fig. 7.

shows a strap being tooled internally with a cutter having the sectional form of the recess in the strap. This machine takes work up to 14 in. in diameter. The drawings (figs. 7 to 9) are given to show details which are not apparent in the photo. They illustrate a machine designed for the same class of work as fig. 6, but larger, taking diameters up to 24 in.; besides which there are some little differences in the details. The construction will be understood by the aid of the following remarks:—

The headstock (fig. 7) is bolted on a base, which has an extension in front of the head, coming forwards, ┐ shaped in plan to carry the circular attachment. The headstock is of ordinary back-geared lathe type, having a steel spindle, with conical necks, and provision for taking up wear. The four-stepped cones and back gears give eight changes of speed. The cutter arbor fits with a tapered shank into the spindle nose, and its outer end is supported by a bracket from the arm overhead, which can be removed when it comes in the way, as for internal milling. In the machine illustrated by the photo (fig. 6) there is no overhead arm and no support to the arbor. In this machine, too, the work in the circular milling attachment is rotated from a single stepped pulley with flanges; in the other (figs. 8 and 9) it is driven from a three-stepped pulley, which can be thrown out of action by a lever and sliding clutch.

The driving is through two sets of worm-gear, seen in the photo and drawings (figs. 6 and 8). The first worm, *a*, driving wheel *b*, is operated from the clutched pulley-shaft, A, through a pair of equal spurs, *c c*, encased. It should be noted that *c c* are really change wheels, and an extra pair is supplied which are not equal to each other. In this way the circular feed can be reduced or increased, and nine different rates of feed are obtained from the three-stepped cone pulley. The second worm, *d*, which is divided to take up wear, is on the spindle of the worm-wheel, *b*. A slow, powerful drive is thus obtained to the

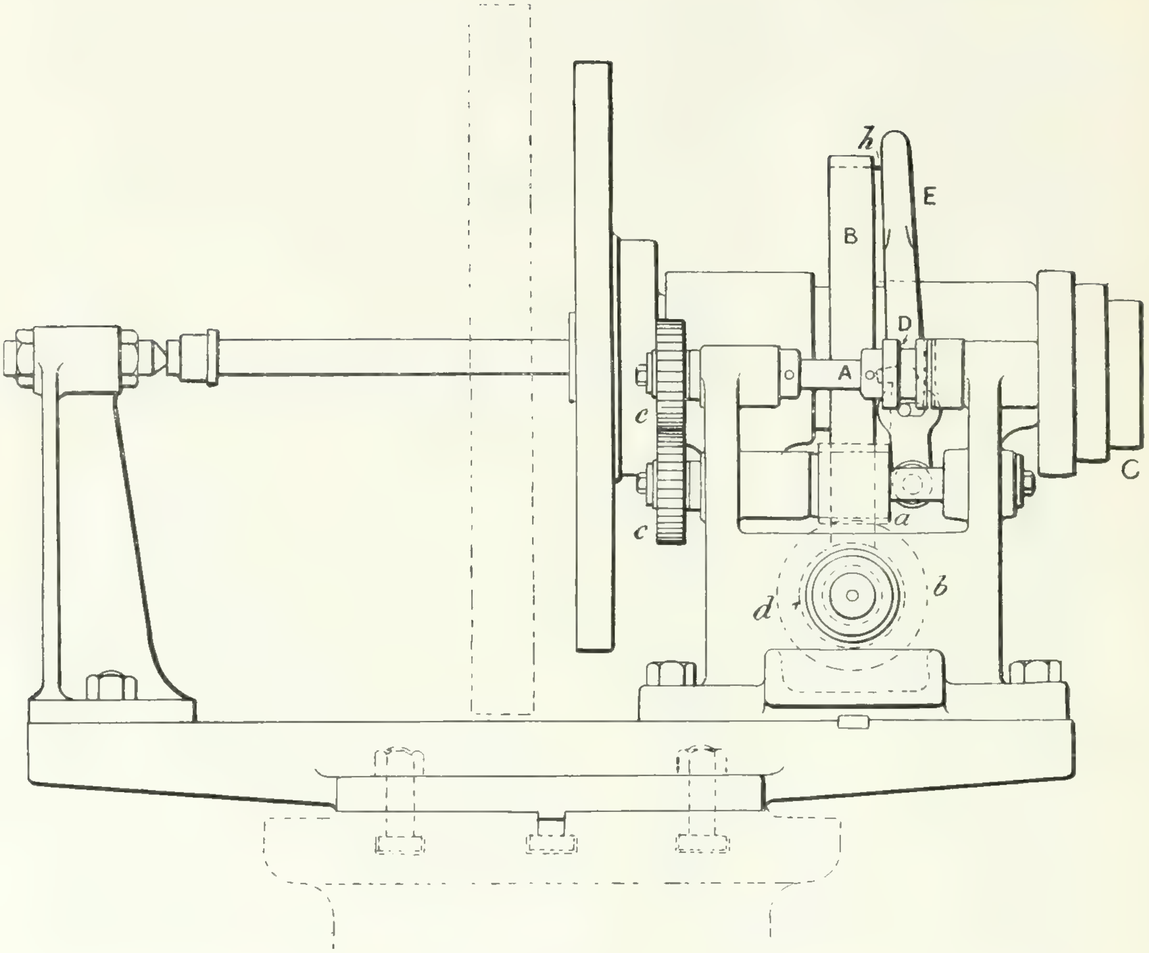


FIG. 8.

wheel, B, which in the case of fig. 8 can be varied by the stepped cone-pulleys, C, on machine and counter. The cross adjustments of the compound slides are effected by hand wheels, but there is an automatic trip and stop motion, which is adjustable round the large worm wheel, B, to arrest the rotation at any point, and which operates by throwing over the clutch, D. The manner in which this is effected is as follows :—

The hand lever, E, has a long boss, and facing this is another boss belonging to a trip lever. A long pin, *f*, connects the two, so that when the latter is moved the hand lever through its slipper block, *g*, throws out the clutch, D. To render the trip automatic at any point, a loose ring, *h*, is fitted against the face of the worm wheel, B. These details are seen in fig. 8, but some of them are enlarged for greater clearness in Fig. 9. The worm wheel, B, has an annular groove, *i*, to receive a couple of locking bolts, by which the ring, *n*, can be secured against the face of the wheel at any position. The object of this is to bring the notch, *k*, in the ring at any desired part of the circle. The notch receives the free end of the trip lever, *e*, which is pushed into the notch on arriving opposite to it by a coiled spring, and so pulls out the clutch, D, by operating the clutch lever, *e*, through the long pin, *f*. The set screw, *l*, can be adjusted to compensate for the wear of the end of the lever in its contact with the face of the ring. The position of the cutter arbor is indicated at F.

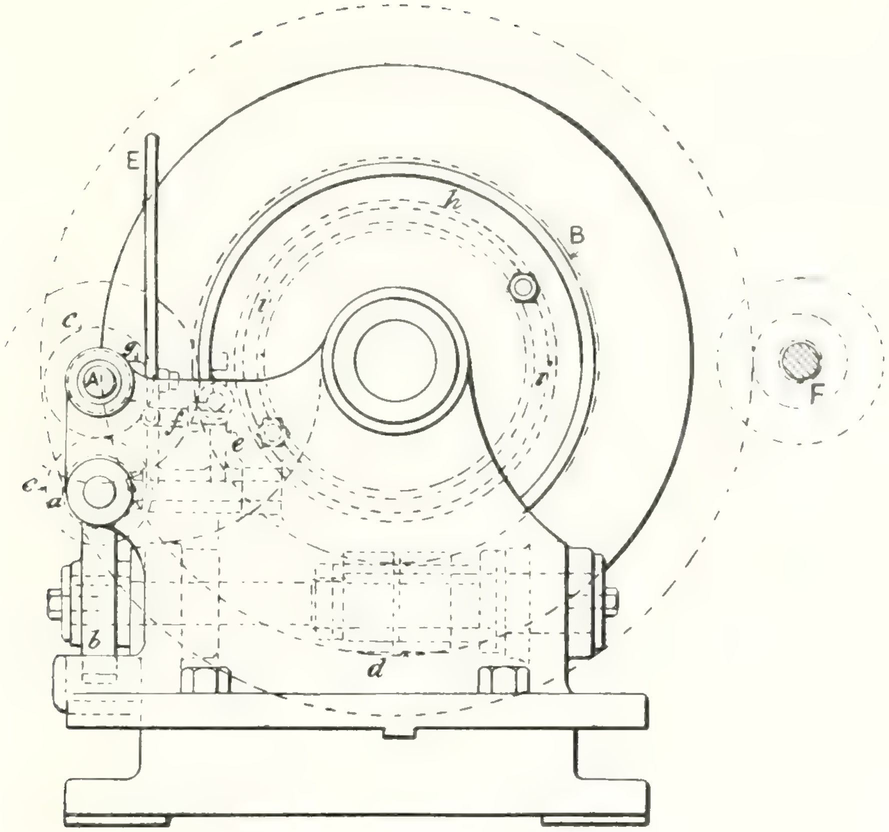


FIG. 8. (SECTION.)

VERTICAL SPINDLE ATTACHMENTS TO HORIZONTAL SPINDLE MACHINES.

Hitherto we have considered the horizontal spindle machines only, and for the greater number of operations which are performed on pillar and knee machines the horizontal arrangement is best. But so many cases arise in which it is either desirable or necessary for the spindle to be set vertically, that a goodly number of machines are made with auxiliary vertical spindles. Several machines, also of the pillar and knee type, have their spindles set permanently in a vertical position instead of horizontally.

One of the principal advantages which the horizontal spindle possesses over the vertical is that both edge and face cutters can be used upon it. The horizontal arbors for edge mills are supported by the overhanging arms, the face mills are carried only by the spindle. In vertical machines, a few of those of large dimensions excepted, no support is given to edge mills beyond that afforded by the spindle, and this limits the depth of work on which they can operate with heavy cuts without risk of chatter.

A vertical spindle attachment is a most useful adjunct for key-seating, and cutting tee slots, worms, and spiral gears, etc., when pieces cannot be placed at right angles with the table. The attachment is supported from the overhanging arm, and the spindle is driven from the main spindle, either by spiral or bevel gears. The spindle is also capable of being set at any angle, from the vertical to the horizontal. A stage further is reached when the attachment is made universal, a design which is added to

Continental machines more than to those of American or English manufacture.

THE NEW CINCINNATI VERTICAL SPINDLE HEAD.

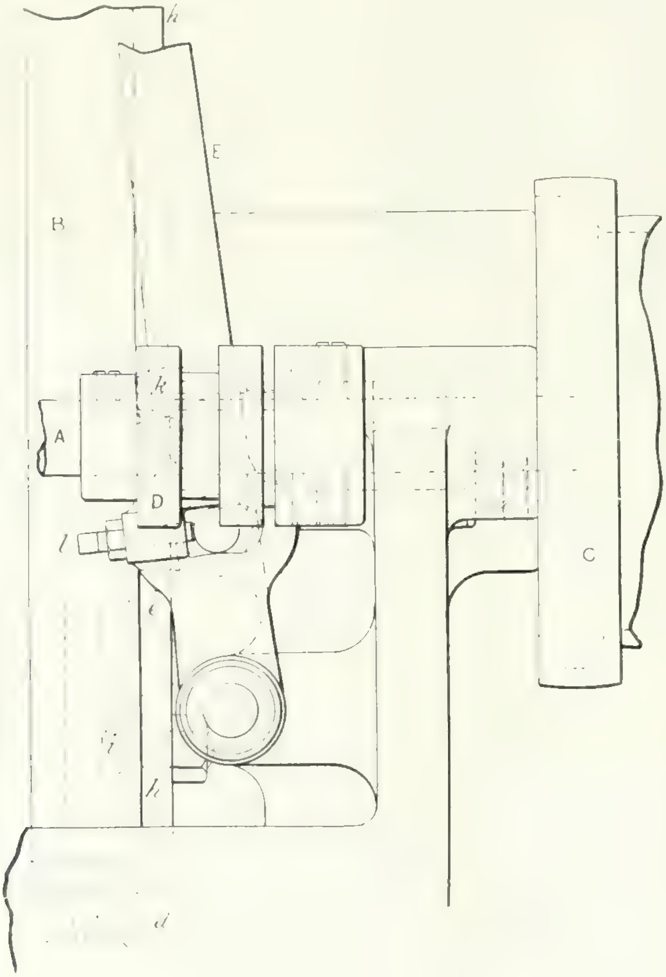
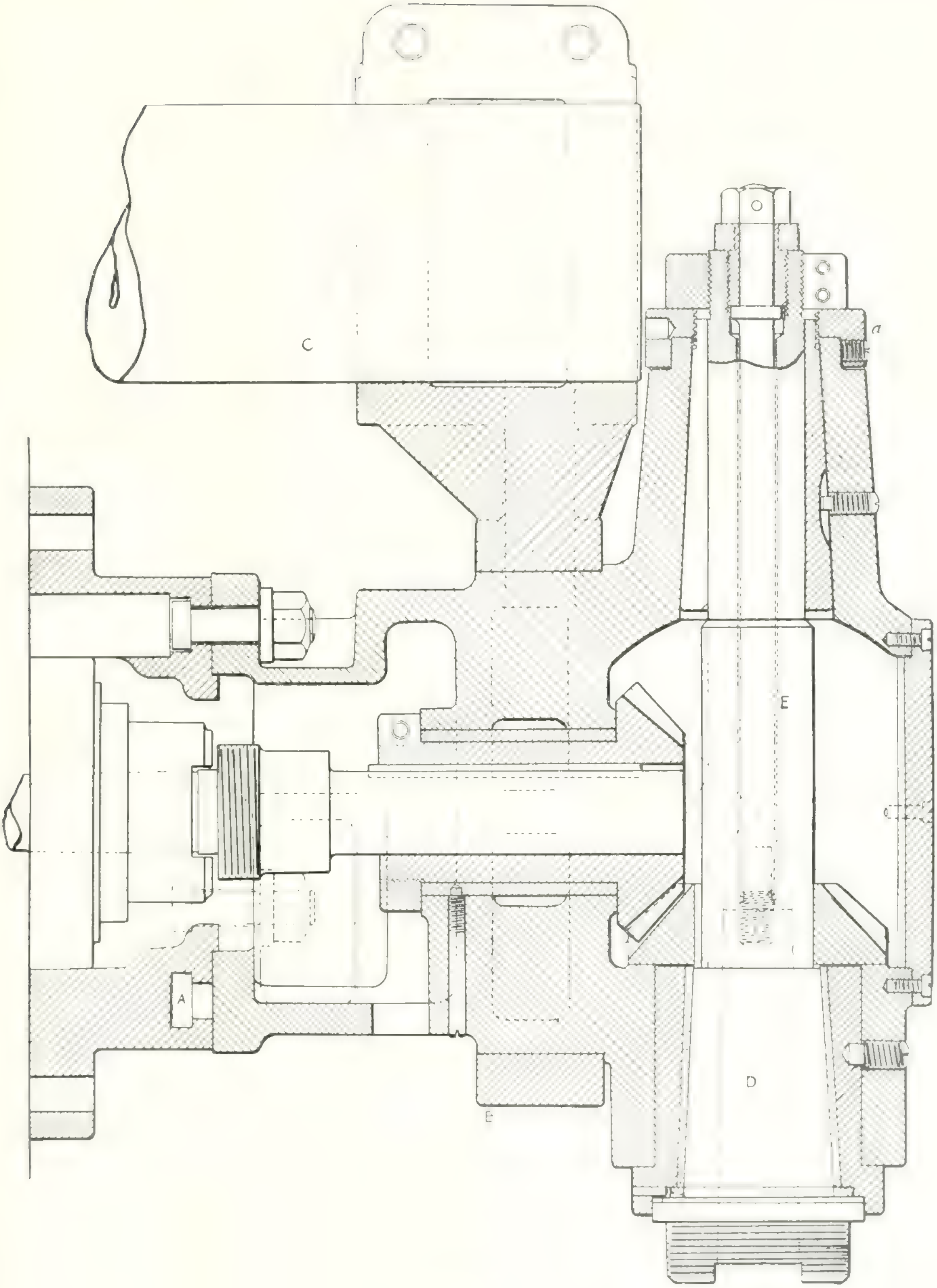


FIG. 9.

The advantages of being able to use a vertical or horizontal spindle at will is the reason of the popularity of that large number of designs in which both are embodied, together with provision for setting the head at any vertical angle. But if the volume of work will justify the laying down of machines of both types, then it is better to keep them distinct. If not, the next thing is to see that rigidity and accuracy are not sacrificed in order to gain the convenience of two-spindle machines. An illustration of what a combination head of this kind should be, is seen in a new one by the Cincinnati Milling Machine Company (fig. 11), and in the sectional elevation (fig. 10). The head can be swivelled in a vertical plane through 360 deg., by means of a circular tee groove, A. The circle bearing the graduations is divided into degrees, and is large, being $8\frac{5}{8}$ in. in diameter, which is an important feature, because it brings the graduations sufficiently far apart to read clearly. Four $\frac{5}{8}$-in. bolts secure the head in place. The body swivels in a bracket, B, that is clamped on the overhead arm, C, which steadies the overhanging portion that carries the vertical spindle. When there is occasion to change cutters, while the work is on the machine, the head can be swung at an angle, and the operator has all the room he


C
a
E
A
D
E

[illegible]

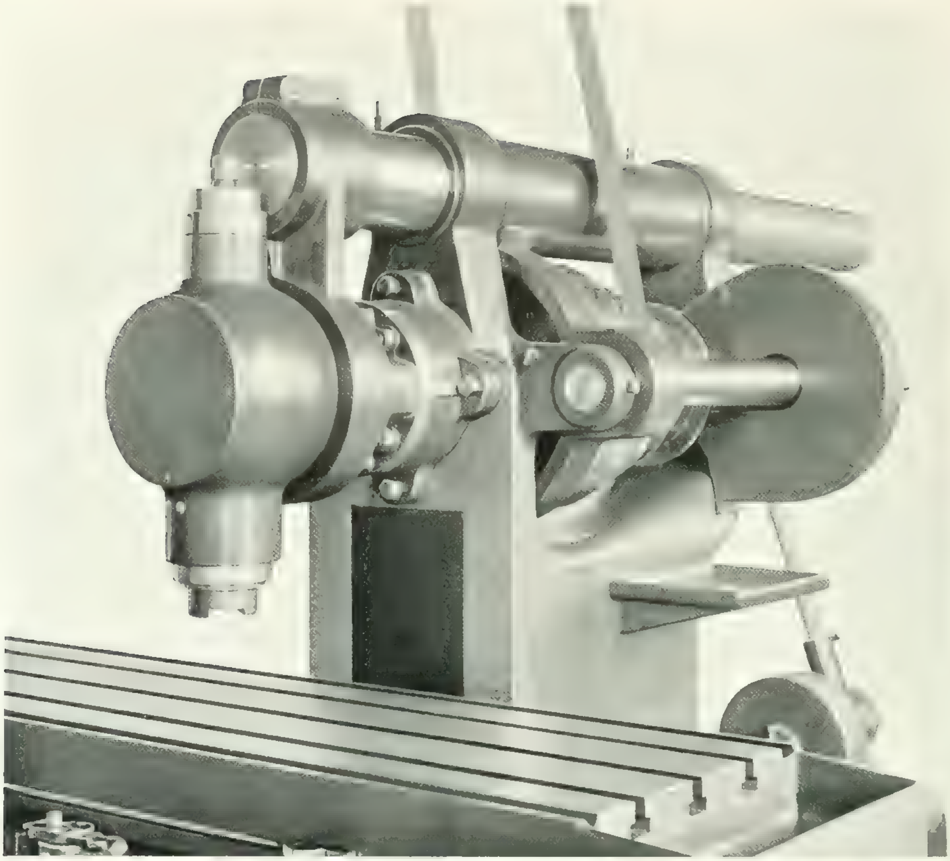
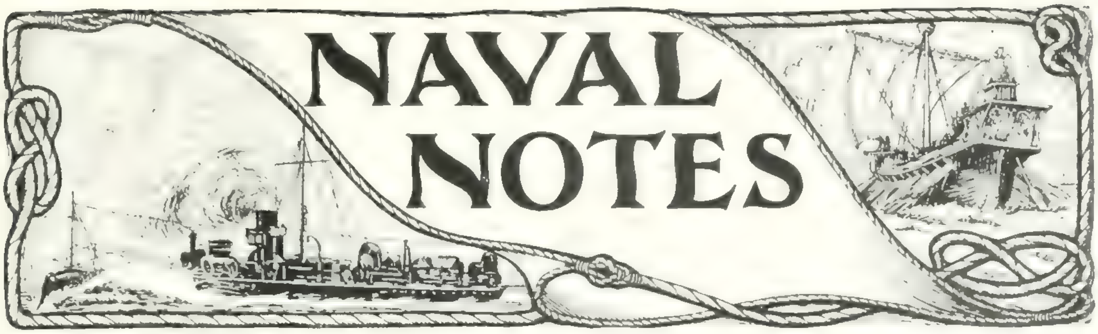


FIG. 11. VERTICAL SPINDLE ATTACHMENT BY THE CINCINNATI MILLING MACHINE CO.

requires for making the change. This obviates the awkward position which often arises from a lack of room for changing cutters on the usual rigid vertical spindle miller.

The spindle, D, is tapered at its lower end, and runs in a babbitted bearing. It is adjusted to this bearing by means of the lock nut on its upper end. The upper box is of bronze, and tapered on its outside. It is adjusted to this end of the spindle by means of the lock nut, *a*, on the box. This method of adjustment is similar to that used on the horizontal spindle of the machine. Particular notice should be taken of the method of securing the cutter shanks in the spindle. These shanks are shaped in the form of a clutch, which matches another on the spindle. This takes the place of the usual tang on the end of shanks. In this case the ends of the shanks are tapped $\frac{5}{8}$ in. to fit the bolt shown at E, and by which they are firmly secured. The bolt is provided with a shoulder near its head so that it can be used for backing a shank out as well as for drawing it in. The end of the spindle is threaded on the outside the same as the end of the horizontal spindle of the machine, and both spindles have the same size taper hole, so that all tools are interchangeable between the two spindles. With this attachment the horizontal spindle miller is readily converted into a vertical spindle machine, capable of doing heavy work, thus embodying in one machine the advantages of both. It will work a 6-in. diameter face mill in cast iron.



NAVAL NOTES

MONTHLY NOTES ON NAVAL PROGRESS IN CONSTRUCTION AND ARMAMENT.

BY

N. I. D.

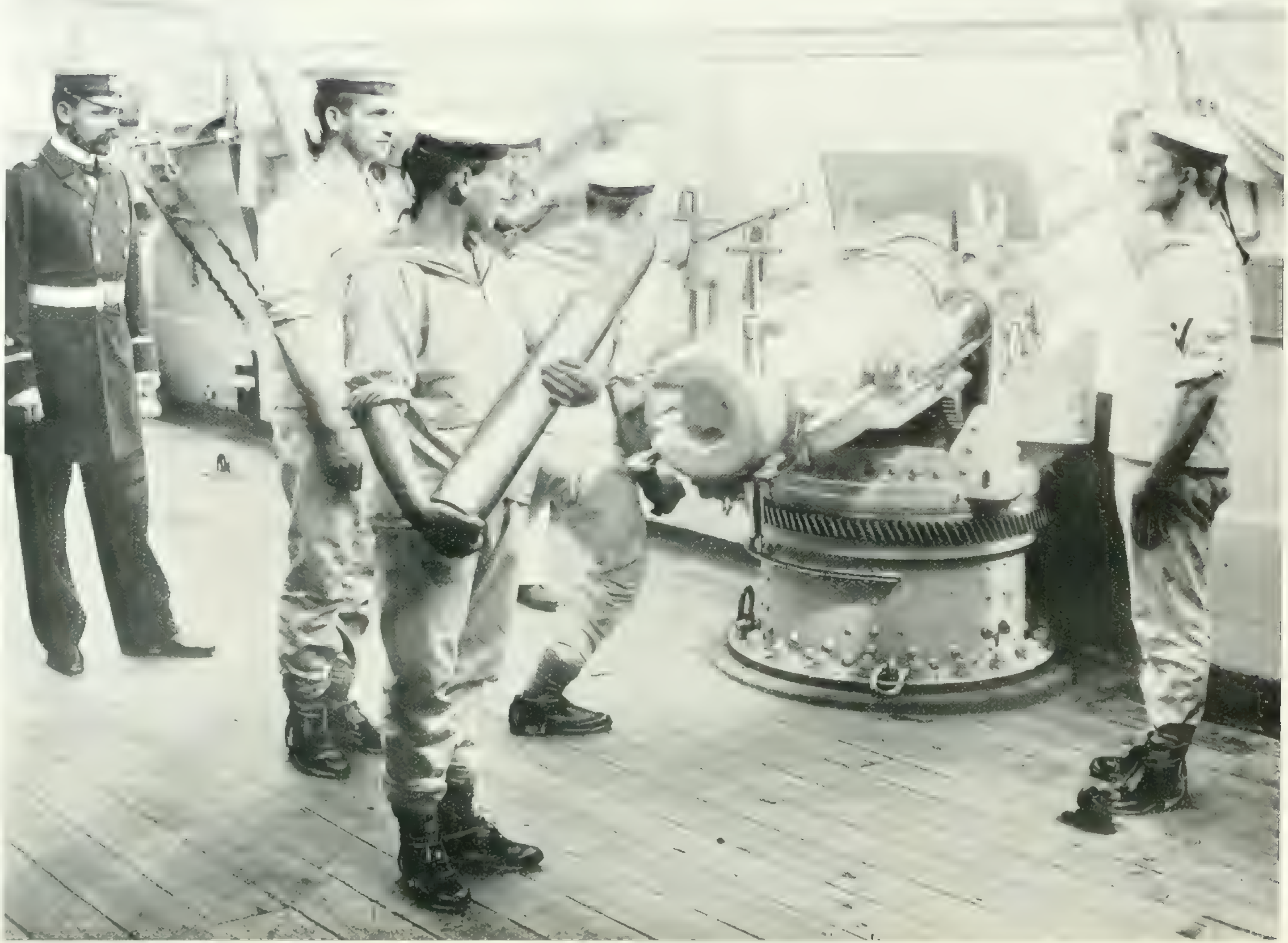
A SURVEY of recent works in the British dockyards does not reveal any great acceleration of pace in construction. The *Suffolk* is still slowly making headway at Portsmouth, where the *Kent* was greatly delayed, and within two years and a-half only two armoured cruisers have been laid down. There appears to have been a great deal of wasted labour, and it would seem that a sounder system was required. A better state of things may follow the appointment of the new Admiral Superintendent, and the building slips should soon be provided with other work. The *Queen* and *King Edward VII.* are going on steadily, but in a rather leisurely fashion at Devonport. Much progress has been made at Chatham, and it is hoped that, with the completion of the new jetty at Pembroke, work will be conducted more rapidly and economically at the latter port. There appears to be no doubt that the new light thrown upon the value of the "Johnson cap" is leading to some revision of plans, and that construction may be somewhat retarded in consequence.

The past month has been a quiet one. The battleship *Venerable* has been under trial, and is to be commissioned for the Mediterranean this month. The *Montagu* has also been undergoing steam trials, and in the four-fifths power trial attained a speed of 17·8 knots as the mean of four hours, with coal consumption of 1·78 lbs. per i.h.p. per hour. She was in an advanced state, and the guns for the secondary batteries had been taken in from the Naval Ordnance Depôt. The armour belt of Krupp steel in the class extends for 290 ft. of the length, with a thickness varying from 3 in. at the bow to 7 in. amidships. The barbettes are protected by 11-in. plates, while the casemates are of 6-in. armour. The thickest armour, 12 in., is that which protects the conning tower. Reference was made in the August number to those ships of this class which had already completed their trials. The *Montagu* has been promised by the officials at Devonport Dockyard approximately for March of next year. She is to pass through a special series of trials additional to the ordinary steam trials, to test her steering capabilities under various conditions of helm at particular speeds, including engine-reversing experiments.

The battleship *Queen* will be completed in March, 1904, and the *King Edward VII.* a year later. The latter vessel, it is estimated, will have cost £1,500,000 by the time she is completed.

Of the armoured cruisers, the *Hogue* is now completed, and will be a valuable addition to the Mediterranean Fleet. The *Bedford* failed to realise the estimated speed on her steam trials, and will be fitted with propellers having a larger blade area, a change calculated to increase the speed by at least half a knot. It is currently reported that other ships of the same class which are under construction have had a similar change made.

The armoured cruiser *King Alfred*, built, engined, and armed by Messrs. Vickers, Sons and Maxim, Ltd., has concluded her thirty and



GUN DRILL ON BOARD A GERMAN BATTLESHIP. KRUPP QUICK-FIRER.

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THE ROYAL YACHT "VICTORIA AND ALBERT."

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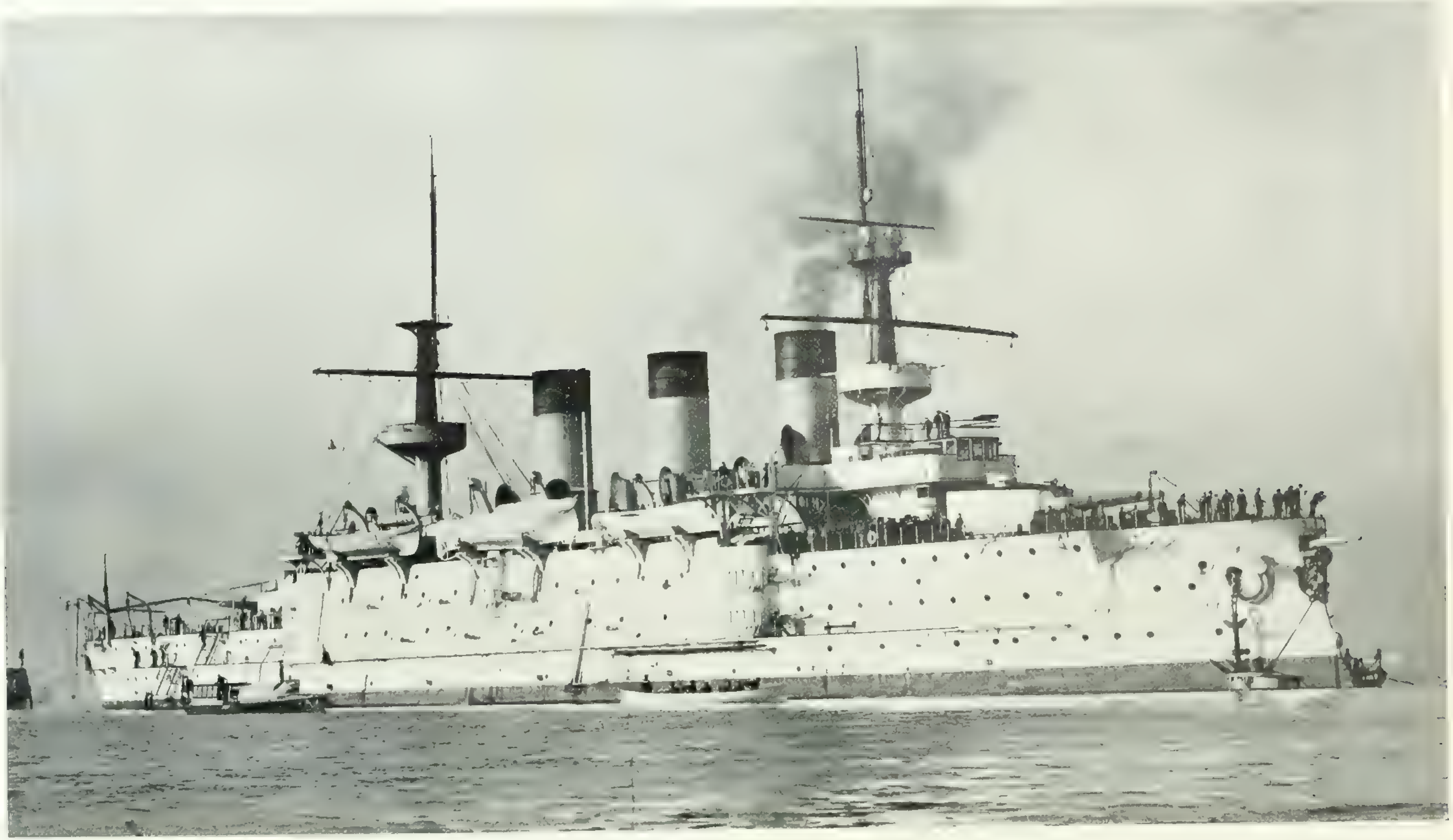


From the Journal of the Royal United Service Institution

THE NEW RUSSIAN FIRST-CLASS BATTLESHIP "PERESVIET."

12,674 Tons; 14,500 I.H.P.; Speed, 19 Knots.

ARMOUR PROTECTION.—Waterline belt, 9·5 in steel; Turret armour, 9 in; Armoured deck, 2·8 in.

ARMAMENT.—Four 10-in., eleven 6 in. Q.F., sixteen 3 in. Q.F., ten 1·8-in. Q.F., and seventeen 1·4 in. Q.F. guns, with six torpedo tubes.

eight hours' steam trials. Her mean draught is 26 ft., but on her trials she was below her stipulated load. The revolutions on the one-fifth power trial were 70 starboard and 70·5 port, with a vacuum of 27·2 starboard and 26·4 port. The collective i.h.p. was 6,395, and the coal consumption 1·76 lbs. per unit of power per hour. The speed realised was 15·167 knots. On the four-fifths power trial the revolutions were 106·6 starboard and 106·8 port, with a starboard vacuum of 26·4 and a port of 26 in. The i.h.p. was 11,316 starboard and 11,289 port, giving a collective of 22,605. The coal consumption was 1·82 lbs. per unit of power per hour, and the speed realised was 21·597 knots. On her full power trials the *King Alfred* proved herself the fastest ship in the British Navy, excluding, of course, torpedo craft. Her mean speed on several runs over the Cheshil Beach course was 23·465 knots, as compared with the 23·23 knots of the *Leviathan*, her sister ship. The coal consumption was also remarkable, for, having established the fact that she could steam from Portsmouth to Melbourne at 15 knots without recoaling, the *King Alfred's* consumption on her full power trial worked out at 1·81 lbs. per unit of power per hour, or 0·13 lbs. less than that of the *Leviathan*. The starboard engine running at 118 revolutions developed 15,170 h.p. with a vacuum of 26·6 in., and the port engine with 119·6 revolutions and 15,723 h.p. had a vacuum of 25·5 in. The water expended during the trial was only 39 tons.

There have been doubts as to the stability of the *Essex* class. Successive orders have been received at Pembroke to reduce the top weights, and the funnels have been cut down. Another vessel of the improved "County" class is expected to be put in hand at the same yard, but it is believed that new views in regard to the defensive power of armour, due to the recent trials of the "Johnson" cap, have caused the plans to be delayed. The *Devonshire*, of this class, was laid down at Chatham on March 25th, and now two others have been ordered—the *Hampshire*, of Messrs. Armstrong, Whitworth and Co., at Elswick, and the *Roxburgh*, of the London and Glasgow Company. The *Antrim*, *Argyle*, and *Carnarvon* will complete the six vessels of the class to be laid down according to the programme of 1901-2. Two others are projected for 1902-3.

The *Niger*, torpedo-gunboat, has made satisfactorily progressive trials preparatory to acceptance of her new Reed water-tube boilers from the Palmer Shipbuilding Company. On the three hours' trial, with 6,282 i.h.p., the speed was 20·5 knots. On the five mile trial the highest mean speed with and against tide was 20·7 knots. The whole of the speed trials were perfectly satisfactory, and were followed by successful circle-turning trials.

Several destroyers have been ordered: *Eden* (Parsons' Turbine Company), *Derwent* (Messrs. Hawthorn, Leslie and Co.), *Ettrick*, *Exe*, *Foyle*, and *Itchen* (Messrs. Palmer and Co.), *Ribble*, *Teviot*, and *Usk* (Messrs. Yarrow).

FRANCE.

The battleship *République* has been launched at Brest, and is a sister of the *Patrie*, which is in hand at La Seyne. She is the largest vessel ever built in a French yard, and is the first to take the water of the five battleships included in the programme of M. de Lanessan, late Minister of Marine, the progress of which, however, appears to be greatly jeopardised owing to the new policy which his successor is endeavouring to inaugurate. The displacement of the *République* is 14,865 tons, and she is 434 ft. 10 in. long, with 79 ft. 7 in. beam. The protection is assured by a water-line belt of Harvey steel, having a maximum thickness of nearly 12 in., while the bows of the ship are to be completely enveloped by 3-in. steel. The armoured deck is 2 in. thick on the flat and nearly 3 in. on the slopes, which reach down below the water level. There is also a splinter-proof deck of thin steel placed horizontally. The armament will comprise four 12-in. guns, coupled in turrets plated with 12 in. of steel, eighteen 6·4-in., of which twelve will be in lateral turrets protected by 6½-in. steel, twenty-six 1·8-in. guns, two smaller, and five torpedo tubes. The speed is intended to be 18 knots without forced draught, and the range will be 4,000 miles at 10 knots, with normal coal supply. The ship has been designed by M. Bertin, who proposed to give the maximum of protection possible, and to place below the armoured deck

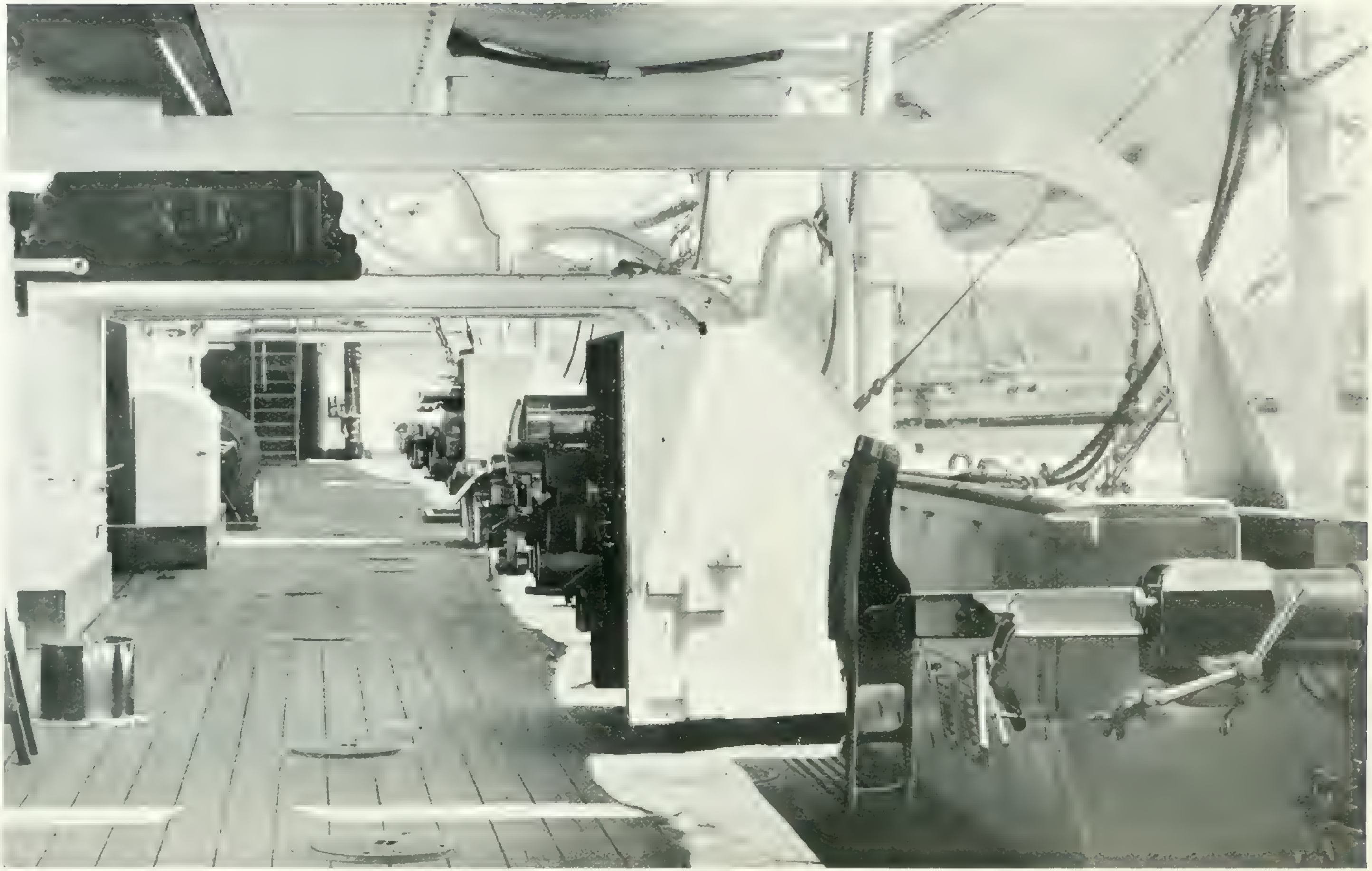


Photo by R. Ellis, Malta.

DECK OF THE SECOND-CLASS CRUISER "CAMBRIAN," LOOKING FORWARD.

and behind the side armour all the vital parts of the vessel. The turret system for the secondary guns, long since adopted by the French, and carried out to a large extent in the new vessels, has now been introduced in British ships of the *King Edward VII.* class.

In a recent return published by the British Admiralty of the navies of the seven great naval Powers, some interesting facts were given concerning the French Navy. Our neighbours have followed our example in putting old vessels on the effective list with the new, but with a difference. Whereas on the Admiralty books vessels armed with muzzle-loaders are still looked upon as effective for coast defence, not one French vessel has a muzzle-loader on board. Built and building, France has 35 battleships, or half as many as Great Britain, and she possesses 45 cruisers already built, and has 17 building, as compared with our 130 completed and 30 or more building. There are also 279 torpedo boats, 31 destroyers, and 15 gunboats built and building on the French list, as compared with 100, 113, and 35 of each class respectively for England.

The armoured cruiser *Jules Ferry* (12,416 tons) is expected to be launched at Cherbourg about March, 1903. Her contract i.h.p. is 27,500, expected to give her a speed of 22 knots. Her engines, which are being made at Indret, will consist of three sets of triple-expansions, with water-tube boilers. The *Desaix*, which has been built by contract at St. Nazaire, will complete her trials at Cherbourg instead of at Brest, owing to the immense pressure of work at the latter port.

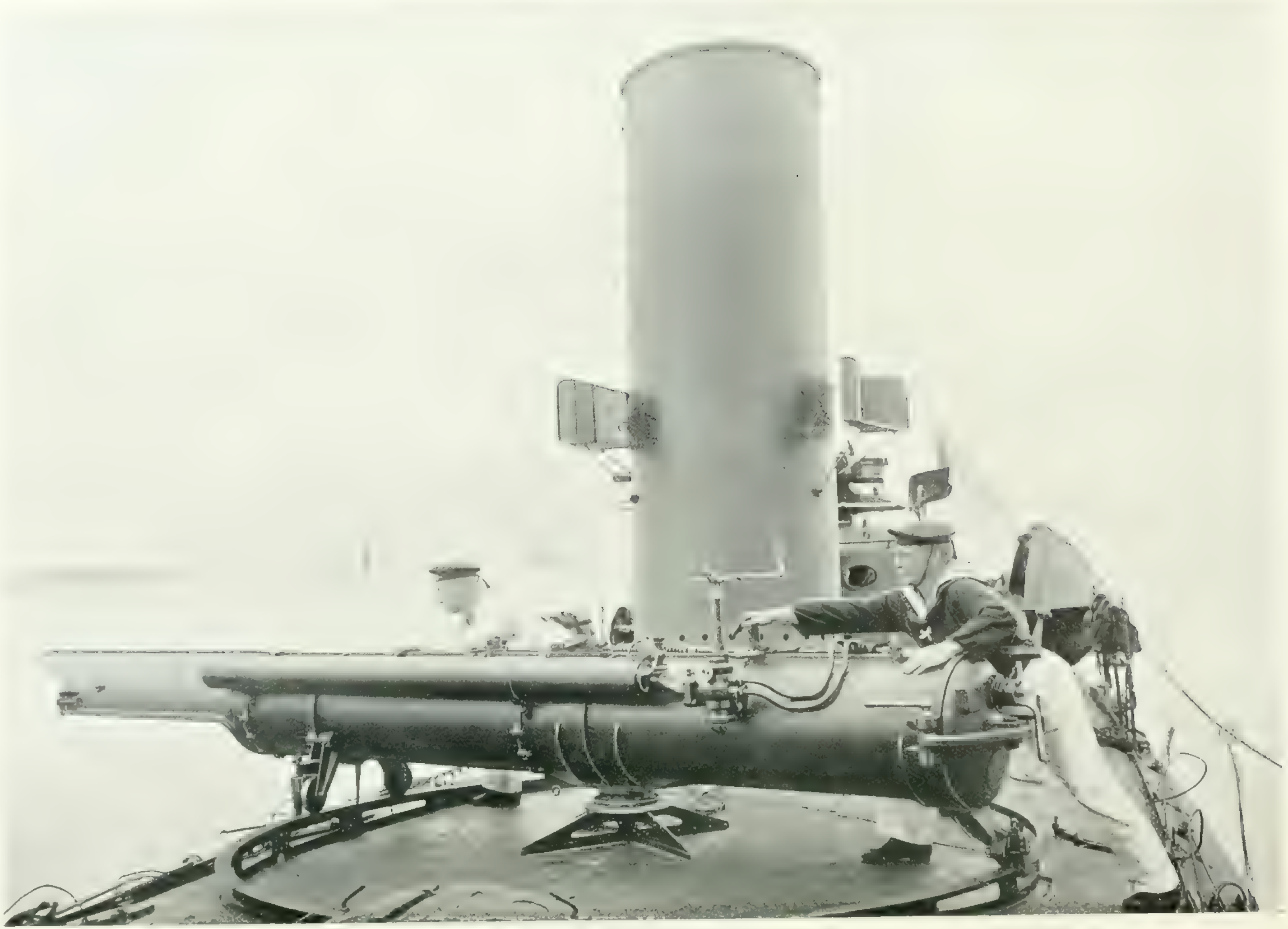
The battleship *Suffren* has just satisfactorily accomplished her full power trials. There is in her an absence of heavy superstructures which have been so marked in some of her predecessors, and she shows many signs of a tendency on the part of her designer to base his plans on the lines of Sir William White's vessels. She has two main and six secondary turrets. She carries sufficient coal for 7,000 miles at 10 knots, and the speed is 18 knots. She is fitted with Niclausse boilers.

The armoured cruiser *Marseillaise* is rapidly approaching completion at Brest. She was only launched two years ago, so that work on her has been fairly rapid. She has all her guns on board, namely, two 7·6-in. breech loaders mounted singly in turrets, and eight 6·4-in. quick-firers, two of which are mounted in casemates with recessed ports on the lower deck aft, two on the main deck forward, and four on the upper deck, in separate turrets. Besides these she has 34 smaller quick-firers and five torpedo tubes, two submerged and three unarmoured above water. She has received her final painting externally, and is of a dull black along the water line and grey for the upper works.

GERMANY.

It is announced that the battleship *J*, which Schichau has in hand at Danzig, being the first of the new type displacing 13,200 tons, will probably be launched before the close of the year, most likely in December. The sister ship, *H*, is expected to take the water at Krupp's Germania Yard, Kiel, next February. The chief advantage in these new ships is that their principal armament will consist of four 11-in. guns, which are somewhat loosely described as "quick-firers." They are the heaviest armament, as compared with 12-in. guns in other navies, and it is claimed for them that they will fire from one to two rounds per minute, whereas the like guns in the *Brandenburg* class can only fire one round in two and a-half minutes. In relation to this claim, it is worth while to note that during the recent prize firing of the *Implacable* in the Mediterranean, in two runs, each of six minutes' duration, thirteen rounds were fired from the 12-in. guns, and that the huge projectiles reached the target eleven times. This aimed firing is a very different matter from a mere record of rapidity in a number of rounds.

The German Government is adhering consistently to the programme laid down in 1900. By that programme 38 battleships were to be built by the year 1916, and 31 of these are now ready or in hand, and it is confidently expected that next year's Budget will include instalments for six others. The twelfth of the 14 large cruisers planned has been laid down this year, and the first instalments for the other two will be asked for in 1903. Progress has not been so rapid with the 38 small cruisers, five only of which



TORPEDO TUBE AND TURN-TABLE ON BOARD FIRST-CLASS TORPEDO BOAT.

are now in hand or ready; but six more are to be laid down next year.

The coast defence armourclads of the *Siegfried* class are being improved successively by being cut in two and lengthened to increase coal capacity and ammunition stores, and the Admiralty propose to devote £750,000 for this purpose. Of this sum £525,000 has already been voted, and the remainder will be in next year's Budget. The name-ship of the class dates from 1889, and the most recent was completed in 1895. The *Aegir* has a complete electric installation for her guns and ammunition, and of the others the *Hagen* has already been lengthened by 25 ft. The four battleships of the *Brandenburg* class are also to undergo changes, £62,500 having already been granted, and the balance of £87,500 will be asked for next year.

Torpedo boat *No. 108*, of 350 tons displacement, has completed her steam trials at Kiel, and has attained a speed of 29·6 knots. The engines gave every satisfaction, and there was little or no vibration. A division of six destroyers is to be constructed by Schichau at Elbing. They will displace 350 tons, be provided with engines of 6,000 h.p., and are to steam at 28 knots. They will be numbered from S114 to S119.

RUSSIA.

The Baltic Yard at St. Petersburg is engaged on a new fast cruiser, apparently for use as a "scout despatch-boat" for the Pacific Squadron. It is believed that the Governor of Kwang-Tung may use this vessel for his sea voyages. Similar vessels will be built for the other Russian Squadrons as soon as this one is completed, which will be before 1904. She will be of 3,000 tons displacement, and her engines of 18,000 h.p. are to be able to develop 25 knots speed. She will be lightly armed with quick-firing guns and torpedo tubes.

The protected cruiser *Askold* has been undergoing a series of progressive trials, which have given the following results: with 55 revolutions the speed was 10·87 knots; with 70 revolutions, 13·70 knots; with 85, 16·35 knots; with 100, 18·85 knots; and with 115 revolutions she attained 20·11 knots.

The *Bogatyr*, building at Stettin, has also undergone steam trials, attaining a maximum speed of 23·45 knots with 20,000 h.p. The *Askold*, laid down in 1899, has a length of 426 ft. 6 in. and a displacement of 6,500 tons. Her trial speed is half a knot better than was estimated. The protection is slight, the thickest armour, 4 in., being that round the casemates, in which 6-in. guns are mounted. There are twelve of these guns altogether, eight behind shields and four in casemates, besides twenty-two small guns and two submerged torpedo tubes. The *Bogatyr* is very similar, her displacement being about 100 tons less. Her speed also shows nearly half a knot improvement, but the arrangement of the armament is somewhat different. Her 6-in. guns are twelve in number, and four are mounted in pairs in turrets forward and abaft, four in casemates, and four in shields on the upper deck. She has twenty-four smaller guns and four torpedo tubes, two submerged on the broadside.

The Nevski Yard at St. Petersburg is about to put in hand two protected cruisers of 6,000 tons and 23 knots, and many torpedo-boat destroyers will also be shortly added to those already in hand there. They are improved *Sokols*, and it is said will displace 420 tons. The *Boiki* and the *Bravi* (350 tons) have lately attained a speed of a little over 26 knots. At the same yard the *Rezvi*, *Retivi*, *Ryani*, *Prosorlivi*, and *Bezuprechni* have been launched. Several destroyers have also been put in hand at Nikolaieff. Experiments have been made with the submarine boat of Lieutenant Kolbasieff at St. Petersburg, and later Sebastopol. No details have been permitted to leak out as to the results. It is confidently stated that several submarines have been put in hand in the Black Sea during the last two years, but extreme secrecy is maintained in regard to them, and no details are known.

Work on various new vessels at Sebastopol and Nikolaieff is being pushed on with what is described as a feverish haste. They include a battleship and a 6,000-ton cruiser.

Lieutenant Zhandr has discovered a new composition for painting the underwater portions of vessels, which has been tried on the ships of the Black Sea Squadron, on the recommendation of Admiral Tyrtoff, Minister of Marine, who is stated to have found great advantages in the use of the composition. Hitherto anti-fouling material has been mostly purchased in this country.

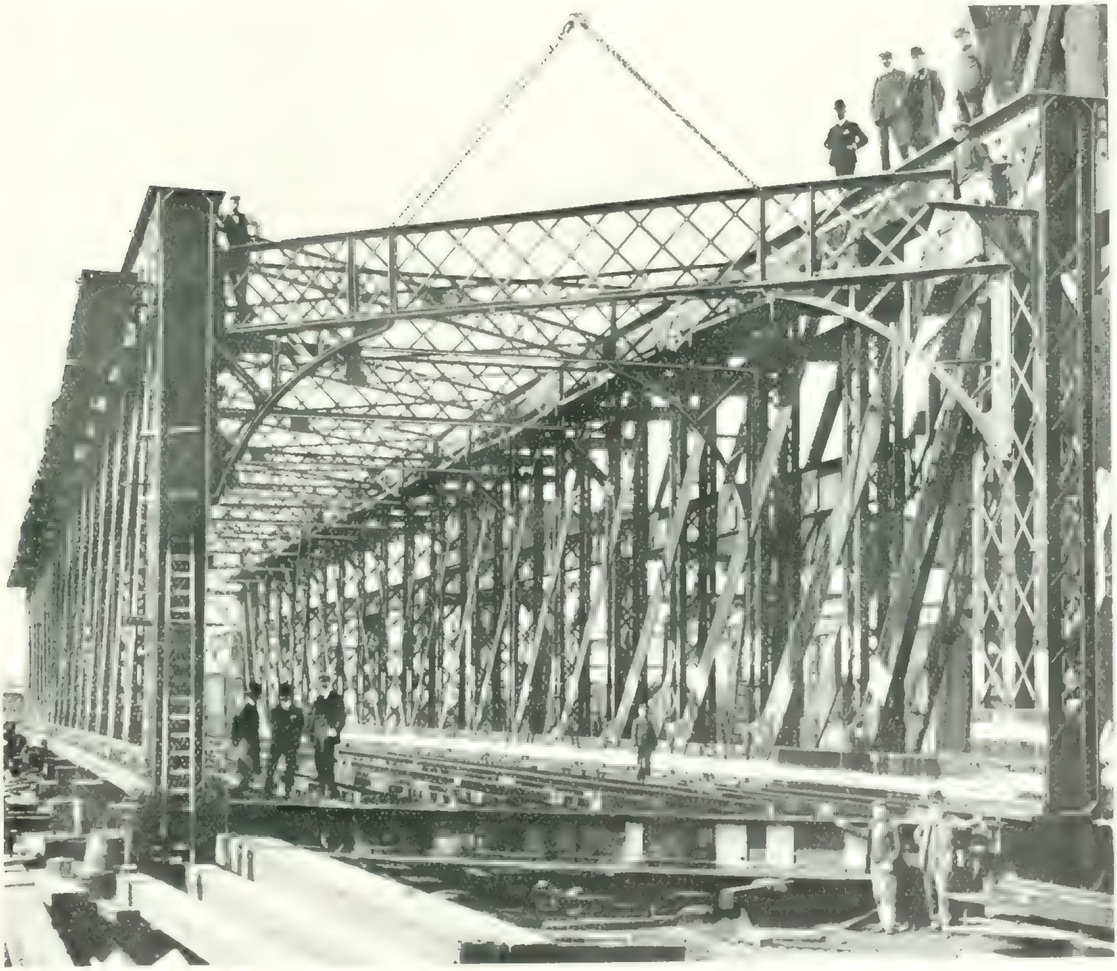
UNITED STATES.

The battleship *Maine* has undergone trials with satisfactory results, obtaining a maximum speed of 18·95 knots. She drew 23 ft. 6 in. and displaced 12,350 tons during the runs. The average number of revolutions per minute was 125. The boilers, of which there are 24, are of the Niclausse type. The complete armour belt is of Krupp steel, 7 ft. 6 in. wide, 11 in. thick above water between the turrets, and 7½ in. thick under water, tapering to 4 in. at the ends. The bulkheads are of 10-in. and the turrets 12-in. armour, while over the battery there is a thinner belt. The protected deck has a maximum thickness of 4 in. The total weight of the armour is 2,453 tons. The armament consists of four 12-in. breech-loaders mounted in pairs in the turrets, sixteen 6-in. quick-firing, two of them in casemates under the forecastle and the others in the maindeck battery, and twenty-four smaller guns, with two submerged torpedo tubes, one on each bow.

The Navy Department have invited tenders for an additional battleship, authorised by the Naval Appropriation Bill, and a sister vessel will be built in the New York Navy Yard. The contract vessel is to be completed within forty-two months. The length at the water line will be 450 ft. and the beam 76 ft. 10 in. The displacement on trial is not to exceed 16,000 tons. The armament will consist of four 12-in. breech loaders, mounted in pairs in two electrically controlled turrets, one forward and one aft, each with a firing arc of 270 deg.; eight 8-in. breech loaders, mounted in pairs in similar turrets at the corners of the citadel; twelve 7-in. breech loaders on the broadside, on pedestals behind 7-in. armour; the fore and aft guns to fire right ahead or right astern, the others to have the usual broadside train. Fifty smaller guns are to be mounted in commanding positions, having a large arc of unobstructed fire. The principal turrets are to have 12-in. plates in front and 8-in. in the rear, and the secondary or 8-in. gun turrets will have 6-in. armour. The total weight of the armament will be 945 tons, and 591 tons of ammunition will be carried. The protection of the hull will be provided by a complete belt 9 ft. 3 in. wide, and with a maximum thickness of 11 in. for about 200 ft. amidships, beyond which the thickness will be 9 in. over the magazine spaces, and will decrease to 4 in. at the stem and the stern. The lower casemate armour will extend in length to protect all the magazines and vital parts, and will rise to the lower edge of the 7-in. casemates, being 6 in. thick, with 6-in. athwartship bulkheads at the ends. There will also be an upper range of casemate armour 7 in. thick athwartships, extending from the shell plating to the 12 in. barbettes. In regard to the speed, it may be remarked that the contract is 18 knots, with 17½ knots as an absolute minimum, and the builder will be subject to a penalty of 50,000 dols. for the first ¼ knot deficiency, and twice as much for the second. There will be twelve Babcock and Wilcox boilers, with 46,750 square feet heating surface. The bunker capacity will be about 2,200 tons, but only 900 tons will be carried on trial. It is particularly deserving of note that in these two battleships the system of superposed gun turrets, adopted in the *Kearsarge* and *Kentucky*, abandoned in the *Maine* class, and resumed again in the *New Jersey* class, has once more been abandoned. It is also particularly noteworthy that the Americans are introducing eight 8-in. turret guns as a secondary armament, compared with four 9·2-in. in our latest class, and twelve 7-in. guns as compared with our ten 6-in. guns for the battery. The result is that the American secondary turret and battery guns will throw a weight of metal of 3,980 lbs., while our 9·2-in. and 6-in. guns will give only 2,520 lbs.

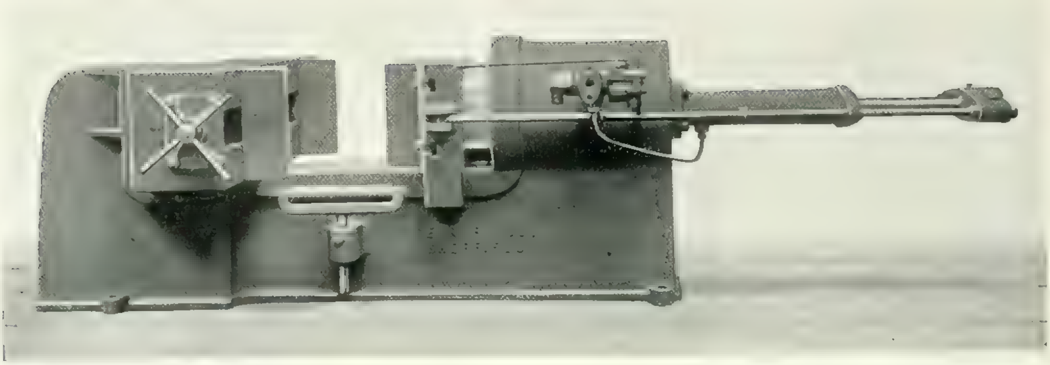
A board of officers presided over by Lieut.-Commander John R. Edwards is conducting a series of liquid fuel tests, in relation to which Rear-Admiral Melville says that oil can be used as fuel with facility, but that it cannot be employed economically in the United States Navy. He does not believe that there is any prospect of liquid fuel replacing coal except perhaps in small craft. The experiments are being continued.

NOTES & NEWS.



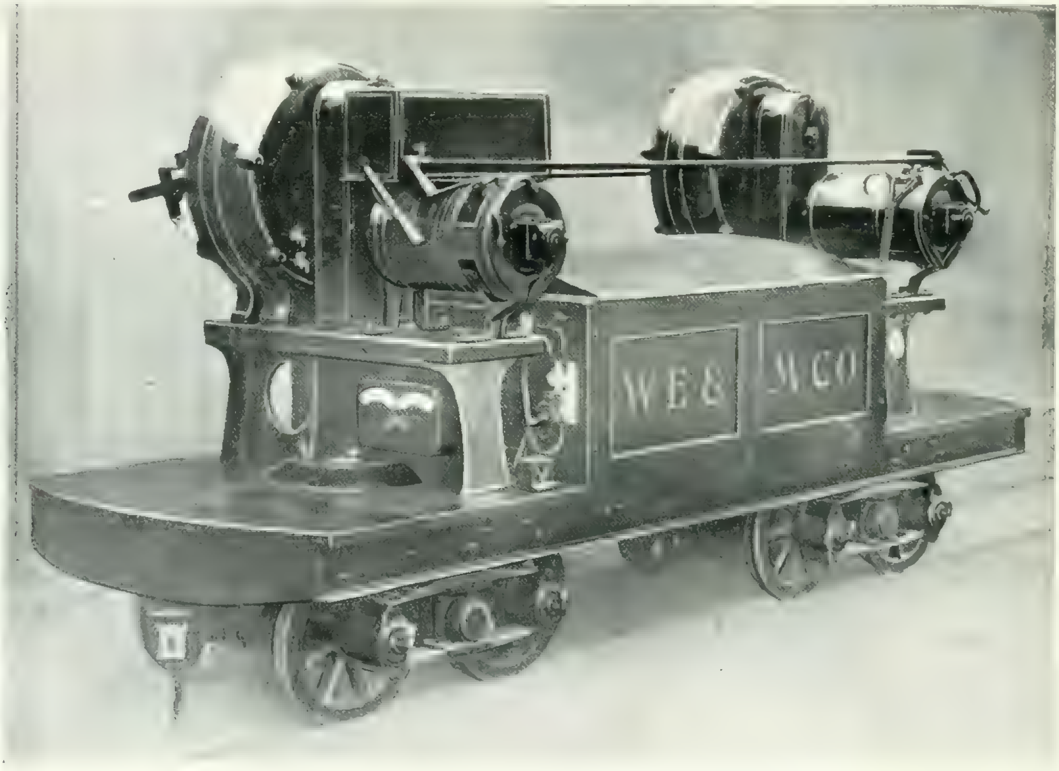
NEW BRIDGE OVER THE RIVER AIRE, NEAR [illegible]

This bridge, constructed by the Cleveland Bridge and Engineering Company, Ltd., Darlington, [illegible] This, allowing for the towing path, involved temporary girders 50 ft. long.



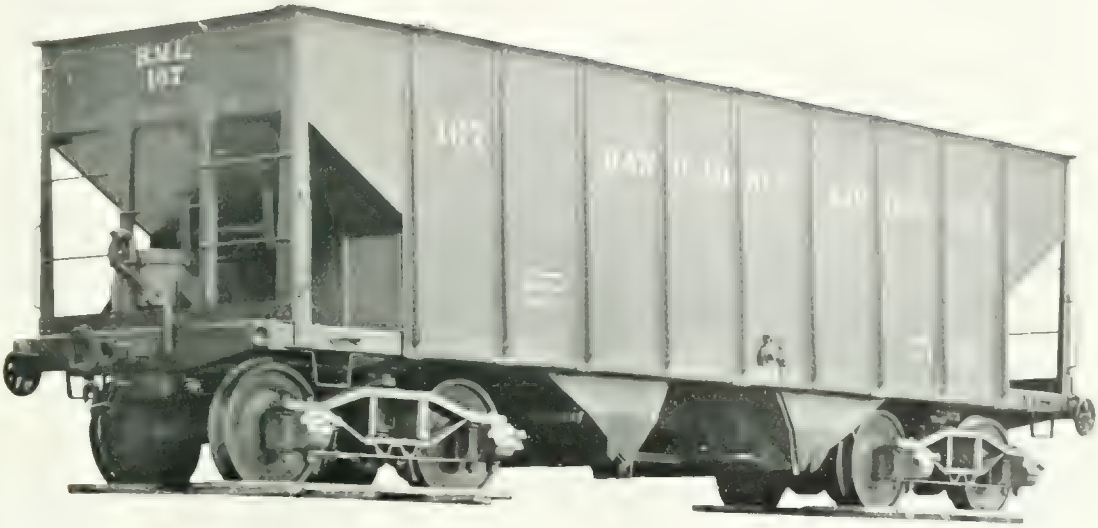
HYDRAULIC PRESS FOR STRAIGHTENING "H" GIRDERS, BENT AND TWISTED OUT OF SHAPE IN COAL MINES.

Mr. George Addy, M.I.Mech.E., of Sheffield, has recently demonstrated that, with his new hydraulic press, illustrated above, twenty-one bent girders can be straightened (cold) in 1½ hours. Formerly, it was considered a good day's work to straighten twenty girders, necessitating an expenditure of 2½ tons of coal, and the services of four men. With this press three men only are required. It weighs about 6 tons, the diameter of ram being 18 in.



NEW ELECTRIC LOCOMOTIVE.

A new Electric Storage Battery Locomotive, supplied by the C. W. Hunt Company, of Staten Island, New York, for the "industrial" railway installed at the Works of the Westinghouse Electric and Manufacturing Company, at East Pittsburg, Pa., U.S.A.



30-TON HOPPER WAGGON.

A 30-ton pressed steel coal hopper waggon, recently built for the Rand Mines, Ltd., South Africa, by the Transportation Development Company, 6, Clement's Lane, Lombard Street, E.C. Gauge 3 ft. 6 in. Weight empty 28,100 lbs.

Messrs. R. Waygood and Co., Ltd., and the Otis Elevator Company, Ltd.

An important amalgamation, consolidating the interests of these two companies, has been effected. Mr. H. C. Walker, chairman and managing director of Messrs. R. Waygood and Co., will be chairman, and together with Mr. R. Percy Sellon, M.I.E.E., managing director of the Otis Elevator Company, Ltd., will act as joint managing director of "Waygood and Otis, Ltd."

The consideration which appears to have determined the directors and shareholders of both companies in favour of uniting the two businesses is that each party is able to supplement the other in important respects, the Waygood Company possessing excellent manufacturing facilities, while the Otis Company controls for the British Empire and Europe, the patents, designs, and wide experience of the Otis Elevator Company of U.S.A. The British and American Otis Companies are quite distinct organisations, possessing only the name in common; but the British company is not only the proprietor of the American company's patents in its territories, but has the immense resources of the latter at its back.

Chain-Grate Stokers.

Messrs. Babcock and Wilcox, Ltd., have just secured from the Underground Electric Railways Company (of London), Ltd., at Lots Road, Chelsea, an order for 128 chain-grate stokers, which are to be used in connection with sixty-four of their boilers, recently sold to this company. This is the largest order for chain-grate stokers that has ever been booked at a time.

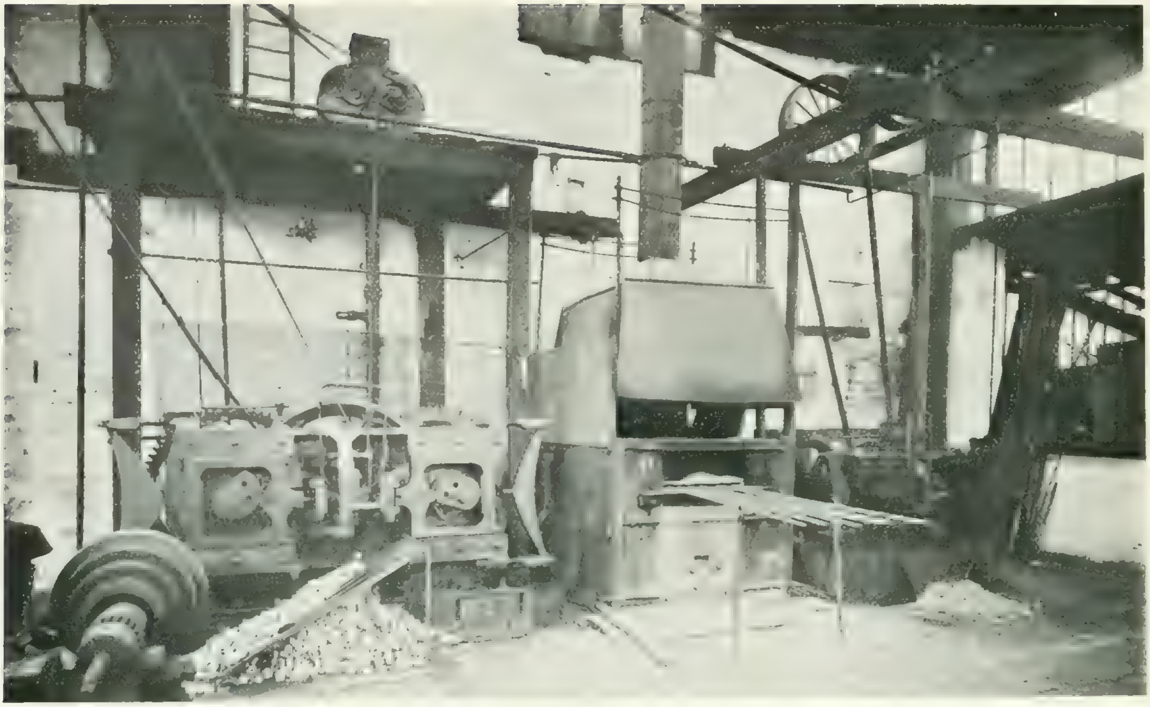
Ore Transport Waggons.

An order for 500 special 12-ton waggons, with steel underframes, has been given to Messrs. W. R. Renshaw and Co., Ltd., by the North British Railway Company. These waggons are to be used for carrying iron ore from the docks to the various iron works, and to convey coal back to the docks.

Korting Gas Engine.

Messrs. Fraser and Chalmers announce that they have secured the manufacturing rights from Messrs. Körting Bros., of Hanover, for the Körting Gas Engine, for use in plants connected with the steel industry, and that they are now prepared to build these engines in sizes up to units of 2,000 h.p.

They have also secured the manufacturing rights for the Stumpf-Riedler system of blowing engines to work in connection with these gas engines. One installation of a 500 h.p. Körting gas engine is now in operation at Duisberg, at the works of the Nieder Rheinische Hütte, and another of 1,000 h.p. at Donnersmark Hütte Works,



LIQUID FUEL FOR NUT-FORGING.

In the works of Messrs. Richard Davis and Sons, Manchester, liquid fuel has lately been successfully employed for heating bars for bolt and nut forging. A greater radiation than that obtainable from coal or coke has been thereby secured, in addition to a marked saving in cost. The bars are afterwards placed in the forging machine, a nut being made at every revolution.

in Germany. These are operating with blast furnace gases. A large order of twelve 2,000 h.p. Körting engines has been recently placed by the Delaware-Lackawanna Steel and Iron Co., of Buffalo, U.S.A.

It is interesting to note in this connection that the exhibition of the Körting system gas engine, with Stumpf-Riedler blowers, is one of the chief features of the Exhibition now being held at Düsseldorf.

Gas Producers, etc.

Messrs. W. F. Mason, Ltd., of Manchester, have been successful in obtaining the whole of the contract of the Bengal Iron and Steel Company, Ltd., for gas producers, connecting tubes, and coal staging for the new steel works plant.

Carborundum.

A test of the various makes of grinding wheels for abrasive purposes was recently made at the Technical High School of Dresden. The tests were conducted under the supervision of Professor Grubler, of the Technical High School, and were intended to demonstrate the operative strength of different makes of wheels Three carborundum wheels were furnished for this test, and these wheels broke the record as to speed, as they were run at 4,340 revolutions per minute. These wheels were made by the vitrified process, and they made a better record than any vulcanised wheels tested. Wheels made by the best manufacturers of emery wheels broke at speeds of 2,720, 2,700, and 2,620 revolutions per minute.

Refuse Destructors.

The judges of the Sanitary Institute have, at the Exhibition in Manchester, awarded the Horsfall Destructor Company, Ltd., the Institute's silver medal (the only award) for their improvements in refuse destructors.

WATER-TUBE v. CYLINDRICAL BOILERS.

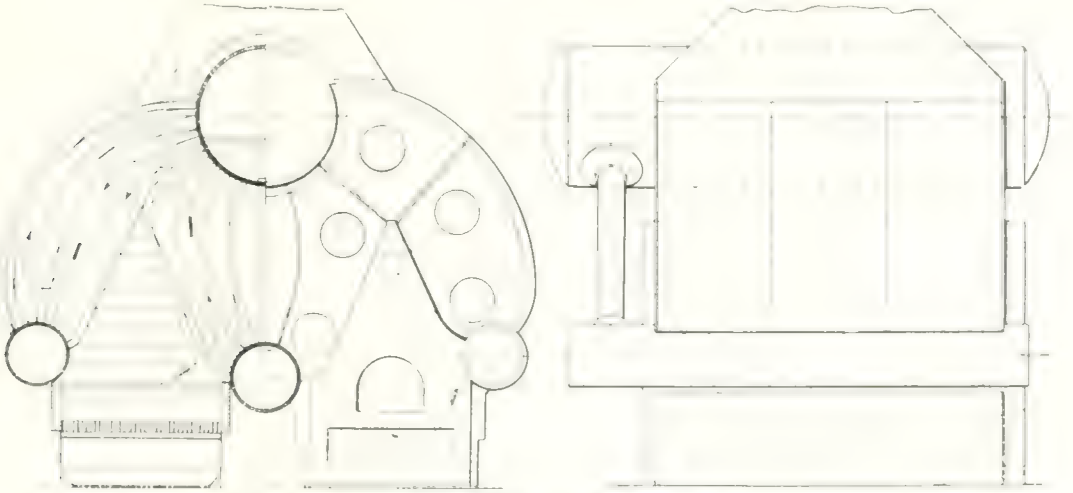
[illegible] being. Upon their soundness depends not only the mobility but the actual existence of the steam vessel, and it is therefore not at all to be wondered at that the subject of naval boilers has occupied during the past two or three years a position of the first importance, not only in the many discussions which have taken place in Parliament during the debates on Navy Estimates, but also in the columns of the press. The following articles—one by an eminent naval engineer, the other by a prominent maker of cylindrical boilers—consider the question "Water-Tube v. Cylindrical Boilers" from diametrically opposite points of view.

WATER-TUBE BOILERS, FROM A NAVAL POINT OF VIEW.

WATER-TUBE VERSUS CYLINDRICAL BOILERS.

THE advantages of water-tube boilers for warship service have met with such general recognition that in one form or another they have been introduced into all the navies of the world. There are, of course, certain points in which they may be inferior to the older types of cylindrical boilers which they are now replacing, but it is the deliberate conviction of the greater majority of people who are competent to give an opinion on this all-important matter, that water-tube boilers have come to stay, and that cylindrical boilers will in future occupy a very inferior position in all war vessels. Indeed, it is probable that in course of time they will be altogether abandoned.

On making a careful comparison between water-tube and cylindrical boilers, we find that



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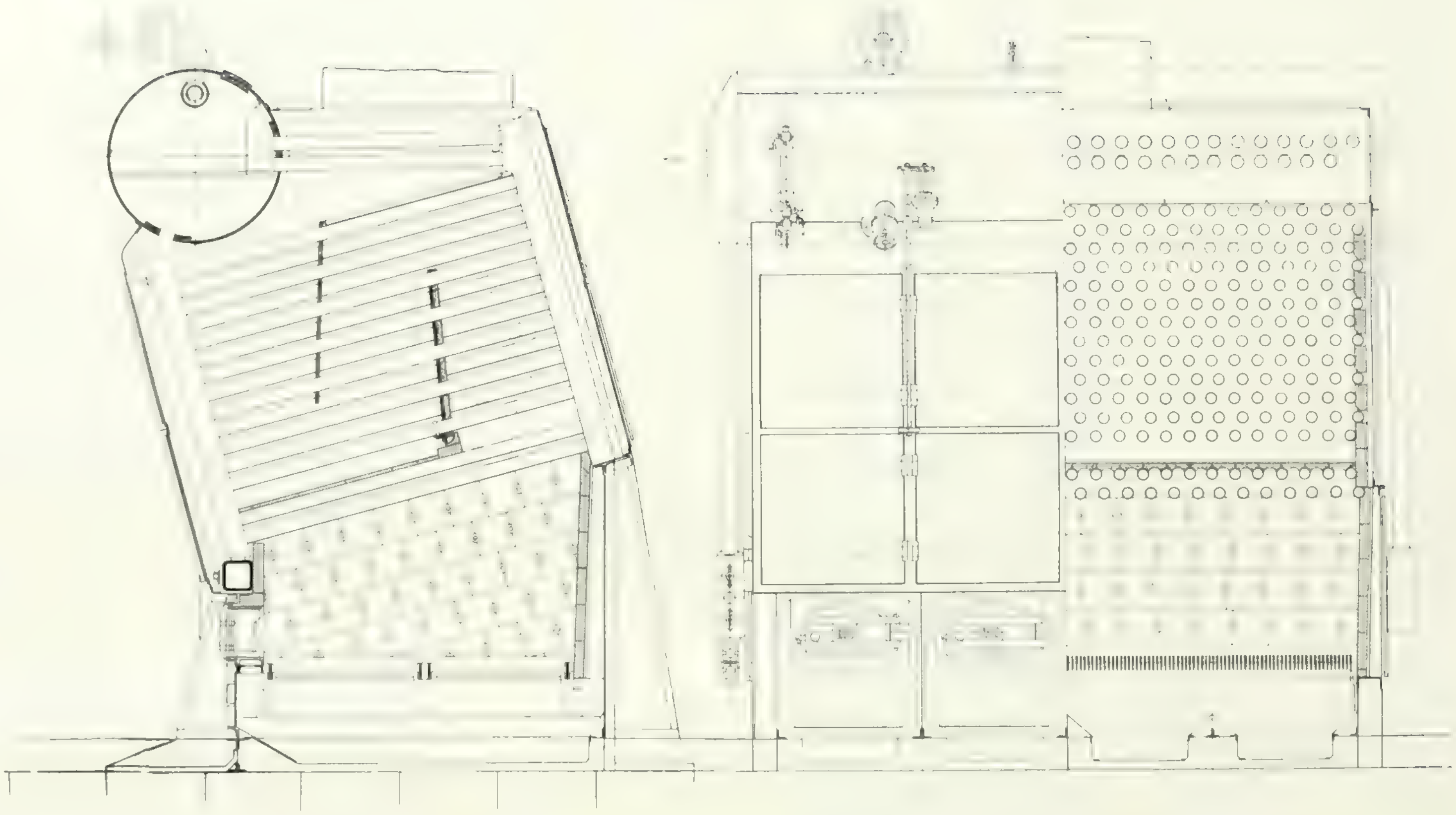
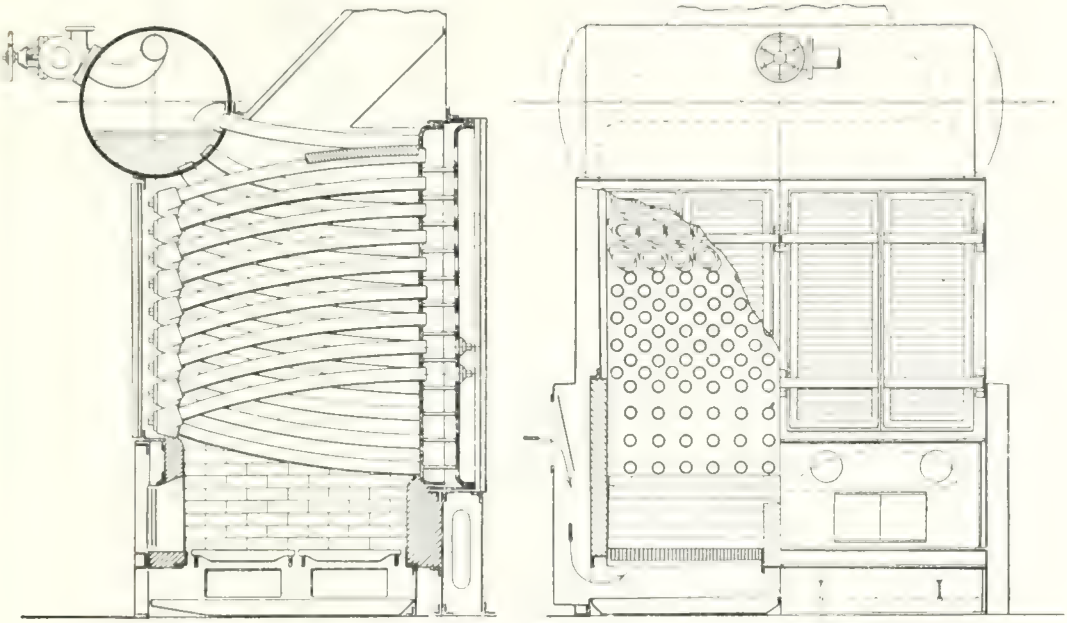


TYPE OF BABCOCK AND WILCOX WATER-TUBE MARINE BOILERS AS FITTED IN THE ROYAL NAVY.



THORNYCROFT-MARSHALL BOILER IN COURSE OF CONSTRUCTION.

the former will raise steam more quickly and maintain it more evenly and at much greater pressure. They can be much more easily renewed or repaired, without having to lay up the ship or pull up her decks for this purpose. They are not so dangerous in action, and will not suffer so seriously from small projectiles. The effect on the ship's company will not be so disastrous in the event of an explosion, because they contain only a very small amount of water for steam generation. They are very much lighter and produce more horse-power per ton of weight, and thus enable advantages to be secured either in speed of vessel or in the amount of armour, armament, or coal supply. They can be "forced" or made to produce a greater quantity of steam for longer periods, and can therefore continue steaming at higher powers, and in this connection also they are assisted by a larger fire-grate area, which enables them to maintain steam for their maximum powers with greater facility.

DISTRIBUTION OF POWER IN WATER-TUBE BOILERS.

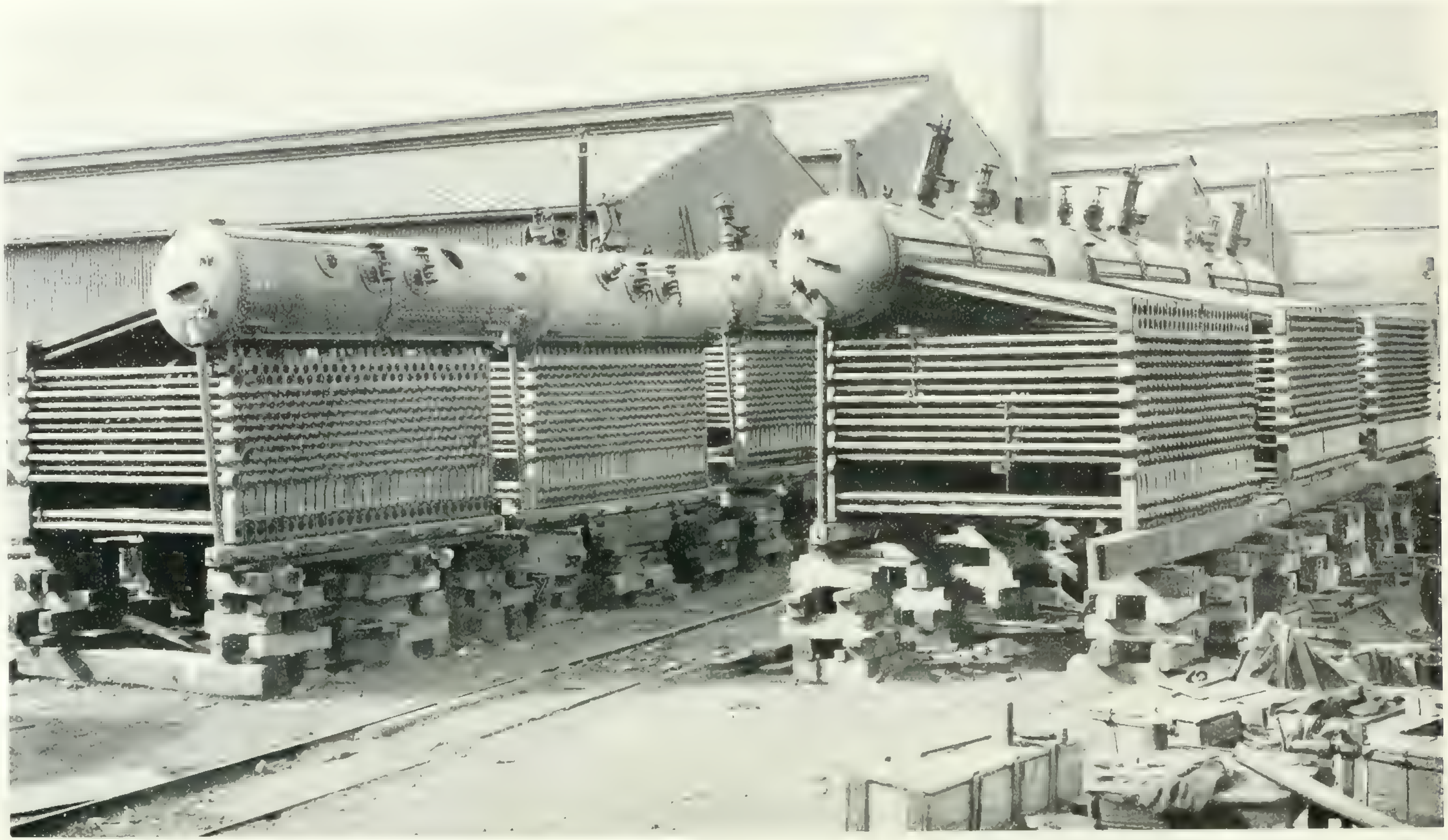
The installation of a water-tube boiler system in a war vessel is always accompanied by the very decided advantage that the total power is distributed amongst a much larger number of boilers than is the case with the older system. Thus a modern cruiser, which would be fitted with twelve boilers of the cylindrical types, would spread its power over about thirty water-tube boilers, and hence the total or temporary disablement of one of the latter would have scarcely any appreciable effect upon the speed of the vessel, whereas if she were to lose one-twelfth of her steam generating power by an accident to one of her cylindrical boilers, there would be a very considerable diminution in her rate of progress.

ALLEGED DISADVANTAGES.

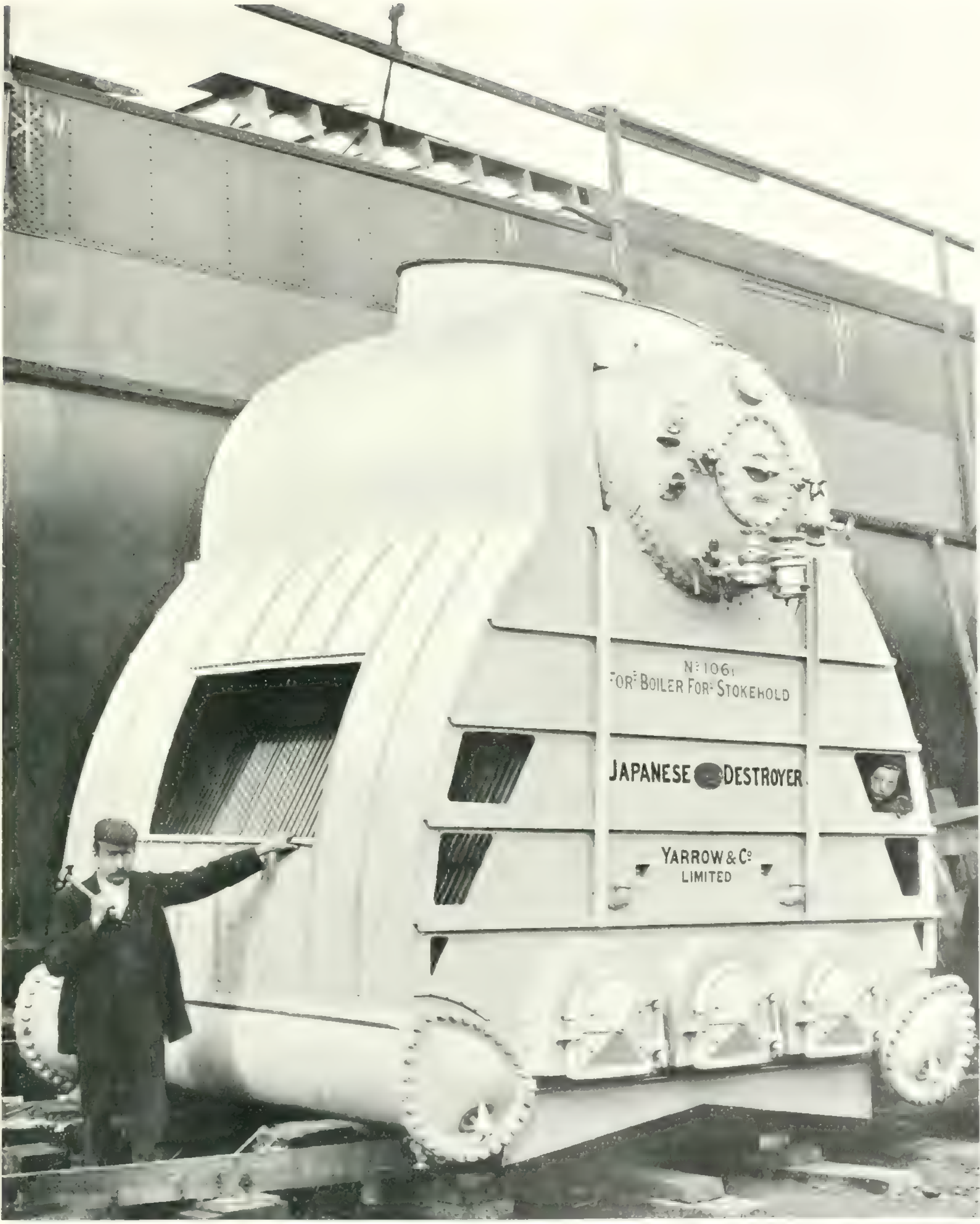
The alleged disadvantages of the water-tube boilers are: That they are less economical in coal consumption per unit of power, that they require more careful stoking, that the cost of their upkeep is greater, that a larger mechanical staff is necessary in order to keep them in repair on account of the necessary multiplication of their fittings and mountings, and that higher engineering skill and attention are necessary for their management and maintenance than is the case with cylindrical boilers.

THE WATER-TUBE BOILER COMMITTEE.

In spite of these alleged disadvantages, however, there is no doubt that for war vessels the



PRESSURE PARTS OF BABCOCK AND WILCOX BOILERS FOR SEAGOING DREDGER "SAMSON."



A YARROW WATER-TUBE BOILER, [illegible]

balance of advantage lies considerably with the water-tube boilers. This was amply confirmed by the investigations of the Water-tube Boiler Committee appointed by the First Lord of the Admiralty in September, 1900. After a few months' labours the members of the Committee were asked to furnish an interim report, in order to satisfy the earnest desire of the House of Commons and the country generally for *bonâ-fide* information. There was at the time some doubt as to the wisdom of the Government in demanding such a report, but as many new vessels were about to be constructed, it was absolutely necessary to come to a decision about the class of boiler with which they were to be fitted. In the interim report, which was forwarded to the Admiralty on February 19th, 1901, it is stated that "the advantages of water-tube boilers for naval purposes are so great, chiefly from a military point of view, that, providing a satisfactory type of water-tube boiler be adopted, it would be more suitable for use in H.M. Navy than the cylindrical type of boiler."

ITS INTERIM REPORT CONFIRMED.

On May 28th, 1902, on the departure of Admiral Sir Compton Domvile, who had been acting as the president of the Boiler Committee, to take up the post of Commander-in-Chief of the Mediterranean, another report, intended to be final upon most of the points which had been referred for the consideration of the Committee, was issued. In this later report the members of the Committee state that further experience has confirmed them in the opinions which they had previously expressed in their interim report of February 19th, 1901; and so it appears to be settled as finally as it is possible to determine such a matter that the water-tube boiler, of some type or another, is to be adopted as the successor of the cylindrical type. This is the deliberate decision arrived at by a Committee of practical engineers of considerable eminence in their profession. They could not possibly be suspected of any bias in favour of the water-tube boiler, and in this connection it is as well to remember that the Committee owed its very existence to persistence, and, as far as possible, complete discussion in the House of Commons. The opportunities of the Water-tube Boiler Committee for obtaining evidence, making practical investigations, and arriving at a sound decision have been unique. The few members of Parliament who pressed their demand, in season and out of season, for an independent inquiry into the system of boilering our warships, are to be congratulated upon their perseverance and patriotism, no less than upon the success which has attended their endeavours.

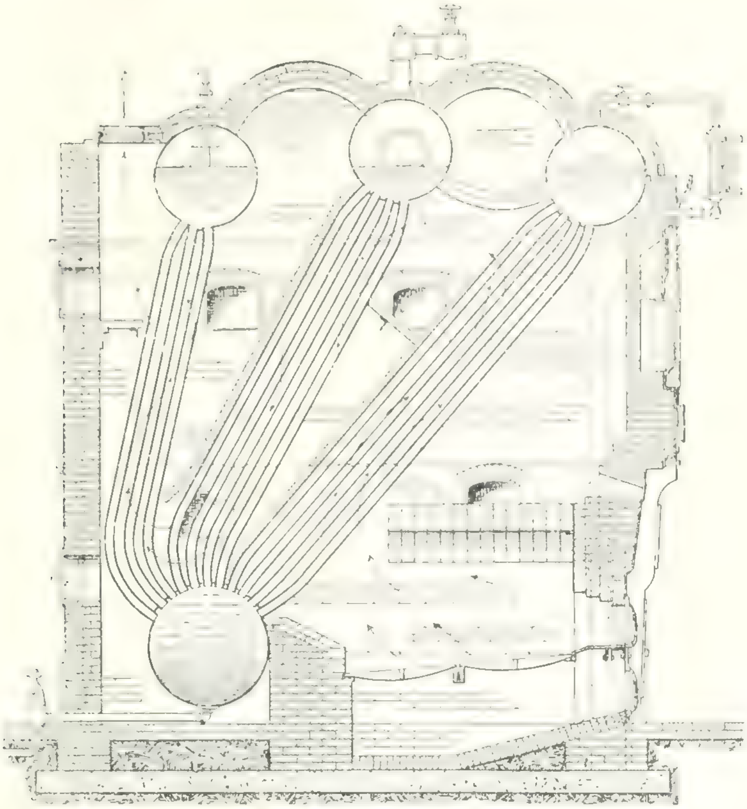
A BOLD DEPARTURE.

The introduction of the water-tube boiler on the large scale adopted in the two huge cruisers *Powerful* and *Terrible* in the year 1895 was the boldest departure in naval engineering practice on record. It was, as might have been expected, attended with much solicitude, and perhaps at times, much excusable doubt in the minds of responsible naval authorities who were not engineers. That in spite of this, the Engineer-in-Chief of the Fleet, after such consideration as he deemed necessary, took upon himself the enormous responsibility of advising this radical and bold departure, redounds infinitely to his sagacity and credit.

INTRODUCTION OF THE BELLEVILLE.

The battle of the boilers may be said to have commenced with the introduction of the Belleville boiler into our vessels of war in the year 1895, but long previous to that date we had adopted water-tube boilers of the small tube type for use in "destroyers." In fact, without a boiler of this kind, the existence of the fast and fragile "destroyer," as we know it to-day, would have been an impossibility. No other type of boiler, except the "express" or water-tube type, would have given the rapid and easy method of steam generation, or would have possessed the merits of extreme lightness and adaptability of being fitted into small vessels.

The destroyer *Havock*, the first of her class, was originally fitted with locomotive boilers, and she was looked upon as the best example of what could be done in vessels of her type; but the performances of the *Havock* have been far surpassed since by vessels which were fitted with the small tube type of water-tube boiler. A very notable case is that of the torpedo gunboat *Speedy*, a small vessel of 800 tons displacement, built by Messrs. Thornycroft, who guaranteed to supply a horse-power



SECTIONAL VIEW OF STIRLING BOILER (UNITED STATES TYPE).

of 4,500 instead of the 3,500 obtained with locomotive boilers in similar vessels of her class, and to do it on a smaller weight of boilers, which should also occupy less space. The saving of weight of water alone in the boilers of the *Speedy* was 20 tons, a very valuable feature considering the important part which weight plays in small, fast vessels of this class. The *Speedy* was a triumphant success, and the adoption of small water-tube boilers for the torpedo gunboats, torpedo boat-destroyers, and all classes of torpedo boats became general.

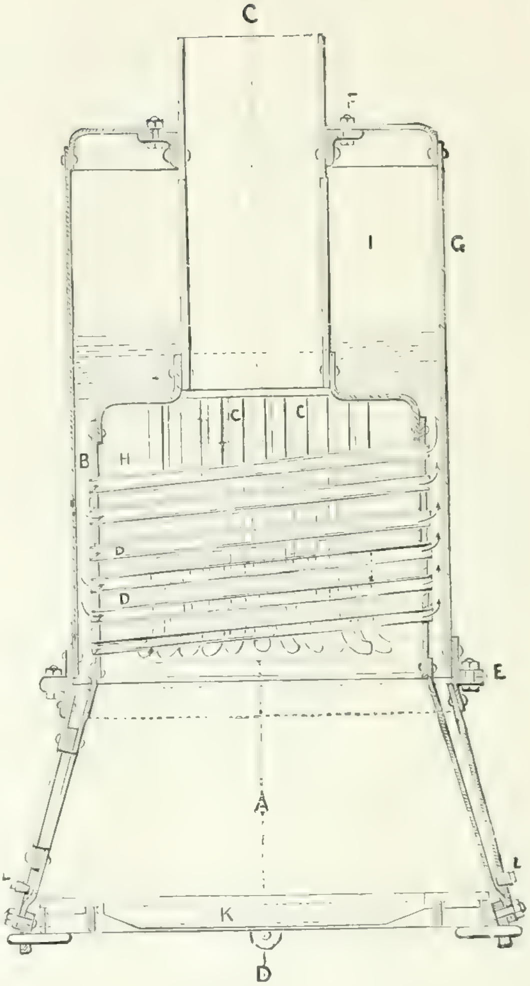
The evolution of the large, fast war cruisers, such as one now sees in the navies of all the important maritime Powers, would have also been impossible without the adoption of a water-tube boiler of some kind or another. For fifteen years or so prior to the introduction of the Belleville boilers into the British Navy, France had been using them in the vessels of her mercantile marine, and had also adopted them for her war navy. It was the only kind of large tube water-tube boiler of which any extended experience had been obtained, and, therefore, having become convinced that a water-tube boiler was an absolute necessity for a war navy, the British Admiralty were perfectly justified in selecting the only boiler of the kind of which anything was known.

UNREASONING OBJECTIONS.

The troubles which have attended its introduction into our service have been seized upon as a reason for objecting to its use altogether. The most wild and unreasoning statements have been made against the alleged unsound practice of boiling water in a tube, by the adherents of the old boiler system, who forget that, after all, a cylindrical boiler is merely a tube on a larger scale. The soundest engineering practice is that which can obtain the best result, and leave the balance of practical advantages on its own side, and this is undoubtedly procured by the water-tube boiler.

ALLOWANCES NECESSARY FOR SEVERE TESTS.

It must be remembered, when comparing the new and the old style of boiler, that at the time of changing the boiler policy of the Navy we had taken at least sixty or seventy years—ever since the birth of the steam engine, in fact—to advance to the steam pressure of 155 lbs. per square inch, which was and still is the practice in the latest examples of cylindrical boilers in our Navy. The large water-tube boilers of the *Powerful* and *Terrible* were designed for steam of 260 lbs. pressure, and in the boilers of the cruisers immediately succeeding them the steam pressure was increased to 300 lbs. per square inch. Thus it will be seen that at practically one step the steam pressures which we had taken seventy years to advance to were doubled, and it is this sudden and enormous increase of steam pressure which has been responsible for many of the troubles of the water-tube boiler and much of the odium which has been unjustly levelled at it by adverse critics.



IMPROVED LIGHT QUICK-STEAMING BOILER, FOR LAUNCHES, ETC.,
BY MESSRS. MERRYWEATHER AND SONS, LTD.

TOO MUCH EXPECTED.

The magnificent performances—and they *are* magnificent—of the large Atlantic liners are quoted as examples of what should be done in large and fast cruisers of our war navy, but a comparison between the two classes of vessels or the two services is utterly impossible. The Atlantic liners are designed for one purpose especially—*i.e.*, to make an ocean passage at the highest possible speed, and no stint is made in any matter which conduces to speed. Weight and space are given liberally to machinery and boilers, and it is scarcely an exaggeration to say that for fast Atlantic steamers the dimensions and output of the engines and boilers are first of all decided upon, and the vessel is then built around the machinery spaces. In war vessels this cannot be done. Weight and space are cut down to the lowest limit, and the engines and boilers have to fit the spaces that can be allowed them in the ships. The task of the engine and boiler designer is more difficult, and the task of the engineer officers and their staffs who run the vessels is of course also more difficult in a corresponding degree. Add to these observations that the functions and duties of a war vessel are altogether different to those of a vessel in the mercantile marine, and it will be at once seen that a comparison between the engineering methods which are respectively adopted to suit the exigencies of a war navy and of a mercantile navy must in the highest degree be misleading and fallacious. The difficulties which have attended the introduction of large water-tube boilers into the Navy have been intensified by the magnitude of the new departure, by the shortage of officers and men of the engineer branch, and by lack of training of the engineer staff in the care and management of these boilers.

The early experiments with the *Sharpshooter*, which was fitted with a small installation of Belleville boilers, and the steam trials and subsequent experience of the two large cruisers *Powerful* and *Terrible*, gave every encouragement to the Admiralty to fit the Belleville boiler into all succeeding vessels. In the earlier cases just mentioned it had been found possible to detail a large percentage of their engine-room complements for duty in the vessels before they were required for commissioning, and although it was only natural in a new system adopted on such a large scale that some difficulties should be met with, there has never been any serious trouble with the boilers of these ships. One of them having already completed a foreign commission, is now again ready for service with the same boilers which were placed on board her in 1895-6, while the other, after having been nearly four and a half years in commission, is just returning from service on the China station.

NECESSARY CONDITIONS.

It is a necessity with an installation of any kind of water-tube boiler that there should be an ample supply of feed water of the purest kind, and to ensure this there should be great care exercised in the design and manufacture of reliable and tight condensers, and the provision of suitable evaporating plant to supply an adequate amount of feed water for the boilers. Troubles which have occurred in many ships owing to leaky condensers, loss of water by leaks from defective steam pipe joints, drains, imperfect workmanship and other causes, are now nearly eliminated, while the longevity of the boilers is being increased by the extra experience which those entrusted with their management are gaining in their care and preservation. The recent report of the Water-tube Boiler Committee is to some extent disappointing, because, while it condemns the Belleville boiler, it does not definitely suggest any other type of water-tube boiler in its place.

THE BELLEVILLE SCARE.

The Belleville boiler has been condemned because up to the present it has been the only type of large water-tube boiler in our Navy with which the Committee have been able to experiment on any scale, but while the members of the Committee have been deliberating, the boilers themselves have been giving much better results as officers and men have gained experience with them. The troubles which have occurred in our Navy with Belleville boilers would have occurred with any other class of water-tube boiler under similar conditions, and they are all connected with causes which lie outside the boilers themselves, and which are now in process of elimination. It is not the purpose of this article to proclaim the merits of any one particular type of water-tube boiler, and if the experience which will be obtained in our new cruisers with the "Babcock and Wilcox," the "Niclausse," the "Dürr," or the "Yarrow" large tube boiler, all of which have been recommended for trial by the Boiler Committee, proves that any one of these types is superior either to the Belleville or to the others, then by all means let the Navy be supplied with the best type we can get. But, in the meantime, there is no reason for alarm, because about sixty or seventy of our largest vessels of war are fitted with the Belleville boiler, which has up to date had to bear the brunt of the battle of the boilers in our Navy. Nearly all engineer officers of the Navy who have had practical experience with this class of boiler prefer it greatly to the cylindrical boiler. The objections of other naval engineers are more theoretical than practical. Admirals Sir John Fisher and Lord Charles Beresford, who have recently returned to England from the Mediterranean Fleet, have probably between them given that squadron more hard and continuous steaming than has fallen to the lot of any other fleet in the world, and in all such cases the ships with water-tube boilers have made the best performances, and have been the most reliable steamers.

CONCESSION TO PESSIMISM.

The phenomenal success obtained in the trials of the four mighty cruisers of the *Leviathan* class, each of which developed easily 30,000 horse-power and attained a speed of over 23 knots per hour, and the more recent trials of the three cruisers, *Powerful*, *Spartiate*, and *Europa*, which have taken place lately in the English Channel, should reassure the public mind on the matter of water-tube boilers. The statement of Admiralty policy which was recently made by Lord Selborne in the House of Lords, leaves no doubt that those responsible for the efficiency of the Navy consider that the water-tube boiler is the best suited for naval needs. The decision to fit the new cruisers of the *Devonshire* class with a combination of one-fifth cylindrical and four-fifths water-tube boilers is a concession to pessimism and sentiment. The practical difficulties in its working probably will be found to overcome its supposed advantages.

WANTED—INCREASED SKILL.

If more than ordinary skill be required for the satisfactory working of water-tube boilers, then it is the duty of the Admiralty to insist on a thorough and comprehensive system of training for the naval engineer *personnel*. Every advance in a science or subject must be paid for in one way or another, and if increased skill and attention be the price required for the undoubted advantages of the water-tube boiler for war vessels, there is plenty of the highest engineering talent in the country which can be obtained, if the Admiralty will only take the proper means to secure it.

CYLINDRICAL BOILERS FROM AN ENGINEER'S STANDPOINT.

According to the evidence taken by the Committee, no type of water-tube boiler at present in use is on general service so economical as the cylindrical. The Committee themselves express the opinion that retarders will be found in many cases to render existing cylindrical boilers even more efficient and economical than they are at present. Until a thoroughly satisfactory water-tube boiler is obtained, the Committee recommend that in large cruisers and battleships cylindrical boilers of sufficient power to work the auxiliary machinery, and to drive the ship at her ordinary cruising speed, should be used with the same steam-pressure as for the water-tube boilers, say 210 lbs. per square inch.

The cylindrical boiler, then, is not played out, and in so far as the merchant service is concerned, nothing so good and serviceable has yet been devised as the good old "Scotch boiler," which superseded the "tank," and which still deserves its name for efficiency, reliability, and persistency, whether or not the time has come for some improvement in the steam-generating plant of sea-going steamers. It has been often said that the progress made in boiler equipment (the most costly and perishable part of the outfit of a steamer) has not been commensurate with that in engine practice. This is not quite true. Fifteen or twenty years ago, eight years was considered a good average life for a marine boiler ; to-day, twenty years is a by no means uncommon age. The type remains, but mechanical progress does not necessarily involve change of type. The Scotch boiler was undoubtedly the founder of the success of the marine engine as we now know it.

The first high pressure Scotch boiler was fitted into the first triple expansion steamer in 1881. This was the *Claremont* of Newcastle-on-Tyne, whose engines were built by Messrs. Douglas and Grant, of Kirkcaldy. Previous to that no boiler builder would undertake to build a boiler for 150 lbs. pressure. The determination of the qualities that go to make up efficiency has not, perhaps, been quite so familiar a study as it ought to be. It is not so many years since the shearing strength of a rivet was considered equal to its tensile strength. Apart from developments in the art of the boiler-maker, however, he has now at his command better materials than ever were known before. If a perfect boiler can be evolved at all, it should be evolved now, when we have the perfection of material and the highest natural and inherited results in scientific insight and technical applications. As far as material is concerned, there is no reason why a boiler should not last thirty or forty years.

The essential condition for all boilers is, of course, that they shall have sufficient structural strength to withstand the ordinary working pressure. But they should also have a margin beyond this, to enable them to work with efficiency even when some parts become thinned by corrosion. Then they should be so designed as to withstand continuously the effects of expansion and contraction resulting from the changes of temperature, not only as to the whole structure but also as to special parts. The design should admit of the furnaces, flues, etc., being readily cleaned, and should provide for the free discharge of the steam produced from the heating surfaces. It is further desirable that the furnaces, flues, etc., should be so arranged as to admit of perfect combustion of the fuel, and of the ready transfer of the heat from the products of combustion to the water or steam in the boiler; for upon these matters economy largely depends. Facility for cleaning the whole of the inside of the boiler is of essential importance. The capability of being "forced," which is possessed by some types, is a distinct advantage. The rapidity with which steam can be raised or lowered, depending largely on the total quantity of water contained in the boiler, and the power obtainable on a given weight, or in a given space, or on a given floor area, are also qualities demanding consideration, as well as the ease with which a defective tube can be plugged or replaced, or other small repairs effected. In the selection of a boiler for any particular service, therefore, all its qualities must be considered, and the type selected should be that which will give more advantages than disadvantages.

In the case of the so-called "Scotch," or cylindrical multitubular boiler, the grates are arranged in circular flues or furnaces, extending from the front of the boiler for six or seven feet into the interior. The flames and hot gases from the fuel rise at the end of the furnace into the flame chamber, which varies in height with the size of the boiler, but is as a rule from two to three feet in width. The tube is one of the walls of this chamber, and it is pierced with holes, through which the tubes are fitted to the front plate of the boiler. When the flames and hot gases from the flame chamber pass through the tubes running parallel with the furnace, the heat so distributed generates steam from the water around the tubes. From the front of the boiler the hot gases and smoke are guided by the smoke-box to the funnel. The tubes are connected with the tube plate by the forced expansion of the metal, which is fitted in cold, and this is where leakage is apt to take place, as the result of the continual play of the flames on plate and tubes. The connection has been found sufficient for ordinary circumstances. But when forced draught is used the cold air rushes in with the hot gases when the furnace door is opened, and causes sudden and violent changes of temperature, by which the tube plate is affected. In a steamer, when the boilers leak under hard pressure of forced draught, the steam may find its way into the furnace and drive the flames out into the stokehold, with serious danger to life and limb of the stokers.

In naval construction the fault seems to have been first in reducing the size of the boilers to save weight, then in introducing forced draught, and then in expecting too much from the boilers as the result. In the merchant service Scotch boilers are generally used with natural draught, though forced or induced draught is frequently applied to them, but in the Navy forced draught is always employed at full powers.

The cylindrical boiler is probably the best in use as far as completeness of combustion of coal is concerned, when worked under ordinary conditions. With skilled attention it is possible to obtain results showing fairly complete combustion in almost any boiler. But as in this boiler all the gases from the front of the fire have to pass over the rest of the fire, meeting at right angles to the streams of gases coming through the back part of the grate, if the fire is of uneven thickness from careless stoking the gases have a probability of mixing together. before passing over the bridge into the combustion chamber, to enter which they have to take a sharp turn at right angles, which again assists them to commingle; and in the chamber they have further opportunities of mixing. Thus the unburned gases become largely consumed before they can get into the tubes, where their temperature is quickly lowered below the ignition point, and no further combustion is then possible. All combustion, then, must take place either in the furnace or in the combustion chamber.

This boiler, further, being less dependent for economy upon careful stoking than most of the other types, has not so much necessity for incessant watchfulness as regards the water supply. The free water area is large, and in ordinary working there are several inches of water above the heating surfaces, so that a considerable amount of water may be evaporated after the stoppage of the feed supply, before dangerous consequences ensue. The roomy steam space and large volume of water contained in the boiler also act as reservoirs of energy, and considerably modify the effects of irregular or careless stoking. This is why Mr. J. T. Milton, of Lloyd's, says that this boiler can be worked with a fair amount of success under conditions which would be disastrous with some types of water-tube boilers.

Long before the Boiler Committee began their inquiry, Mr. J. T. Milton pointed out the very different conditions between the services required in merchant and in war vessels, which early led to differences of practice in the construction of their boilers, even at a time when the tank boiler was considered the only possible type. The boilers in merchant ships were much larger in relation to the power of the vessel, having more heating-surface in proportion to the grate surface, and having also much wider water-spaces, in order to render them more accessible for cleaning. In all merchant vessels, except perhaps in a few engaged only on short runs, economy of fuel and durability of boilers are matters of the very first importance. In most cargo vessels, owing to the peculiarities of the tonnage laws, the space occupied is of comparatively little moment; and even in mail steamers of large power a saving of weight or of space would be dearly bought at the expense of increased coal consumption or of decreased durability.

In war vessels, however, very different conditions prevail. In their case, weight and space are of vital importance; and, although economy of coal consumption and durability are desirable qualities, the necessity of having at command the highest speeds obtainable, especially in certain classes of vessel, justifies some departure from the practice which would otherwise obtain. "In merchant vessels," says Mr. Milton, "only the full power is required, and both engines and boilers are designed for maximum efficiency at this power. In war vessels the maximum power is rarely required for extended periods, the greater part of the work being performed at relatively low powers; and the necessity of steaming long distances at the most economical speeds renders economy at low powers of more importance than at high powers. Instead of the uniform speed required in merchant vessels, war vessels must be capable of quick manœuvring, necessitating sudden and large changes of power, and must therefore possess the capacity of raising and lowering steam quickly. In them, also, there is the possibility that their boilers, steam pipes, or engines might be damaged by missiles—a contingency which need not be considered in merchant ships. These are some of the considerations which show that the design of boiler most suitable for one vessel might not necessarily be the best fitted for the others. The conditions in the different classes of war vessels even are not the same, so that it by no means follows that a type absolutely necessary in, say, the torpedo-boat destroyer, would be suitable for a battleship."

No change of type, either of engine or boiler, will commend itself to merchant shipowners unless some distinct gain is thereby assured; if, however, a change, and a further advance in economy, is to take place, it must be remembered that increases of steam pressures above the present high pressures of 180 lbs. and 200 lbs. per square inch, will not be likely to give such relative increases of economy in the engine as were obtained in the past by increases above the lower pressures formerly used.

In the merchant service the boilers used are almost universally cylindrical, with internally fired furnaces and smoke-tubes. The pressure is usually 160 lbs. per square inch, although in some cases 200 lbs. per square inch has been employed, and in a few cases even up to 250 lbs. As heavy repairs and renewals of these boilers are serious matters, it is necessary that they should last for many years, but it is also important that they should be economical in fuel consumption. This, indeed, is the motive which has led to the gradual increase of steam pressure to the present point, which many engineers consider to be the maximum which can be obtained with this type of boiler. If water-tube boilers are to supersede the cylindrical in merchant steamers, they will have to be proved to be at least as economical in fuel consumption in proportion to the evaporation obtained, and new types of engines will have to be made to utilise properly the higher pressures of steam the water-tube boilers will render available.

Experts differ, of course, as they always do, as to the cause which brings about leakages. One theory is that the fault is due to a want of elasticity in the tube-plate, and that it ought to be much thinner than it usually is. Experiment has shown that the part of the tube-plate nearest to the fire expands more than the upper part, thus giving the plate a tendency to curve, and the contention is that tubes of equal length connected with the plate must become distorted when the plate curves, besides the molecular strain on the tube-plate due to the two sides being subjected to different temperatures. Others, again, contend that the strain which causes the leakage is due to the tube-plate being overheated in consequence of deficient water circulation in the boiler, and especially immediately inside the tube-plate.

Some of the experiments of Sir A. J. Durston, Chief Engineer of the Royal Navy, were made with a view to proving this. A few years ago he applied forced draught and an improvised arrangement corresponding to a boiler, until the tube-plate became red-hot at 1,400 deg. F., and when the boiler was cooling there was leakage. The point to which the tube-plate in this case could be heated without subsequent leakage was 750 deg. F., and it was ascertained that a deposit of grease inside the boiler resulted in a loss of efficiency to the extent of 8 to 15 per cent. Tests were also made to ascertain the temperature of the gases in their course from the fire through the tubes in a small boiler. Starting at 1,644 deg. F., in the combustion chamber, they entered the tubes at 1,550 deg. When they had passed over 1 in. the temperature was 1,466 deg.; at 2 in., 1,426 deg.; at 3 in., 1,405 deg.; while at 8 in., it recovered to 1,410 deg., and at 14 in. dropped to 1,368 deg., continuing to fall to 887 deg. at 6 ft. 8 in. Two-elevenths of the fall, therefore, took place in the first 2 in. of the tube, so it is quite evident that the greatest generation of steam is in the vicinity of these two inches, or practically close to the tube-plate. If the water there does not circulate satisfactorily there is a tendency to overheat.

A discussion of all the theories, however, is too large for our present purpose. Many engineers look very hopefully on the tubular-boiler, not so much on account of the defects in the multi-tubular, as of the objections to its weight and the weight of water it contains—objections which, of course, have most strength in regard to high-speed steamers. There are two fixed and distinct classes of water-tube boilers, those with large tubes and those with small tubes. The former have found most favour where considerations of weight are not extremely urgent. It is noticeable, however, that of recent times the tendency in large tube types has been towards a smaller size of tube, and in the small tube type towards a somewhat larger size.

ESTIMATES.

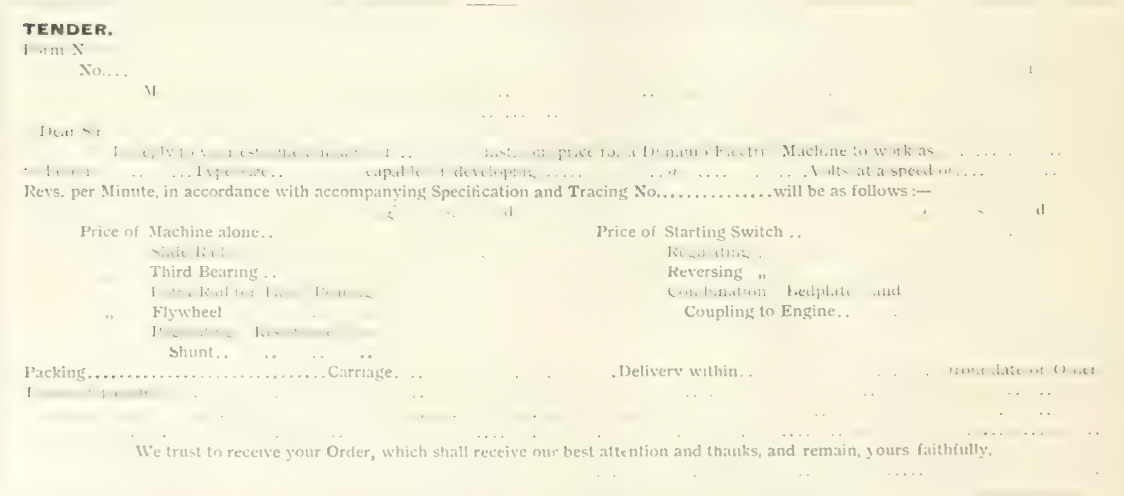
BY

CLAUDE W. HILL, Assoc.M.Inst.C.E., M.I.E.E.

A GOOD system of prime costs is a great help in the preparation of estimates, especially as a guide to the probable cost of labour, and a correct system of ascertaining the percentage of standing charges to be added to the bare cost of material and labour is of great importance. In many cases in which losses in trading have been incurred, analysis has shown that estimates as a whole have been correctly made so far as actual cost of material and labour have been concerned, but that the prices taken have been too low owing to the percentage added to cover standing charges being under estimated.

It is advisable that all estimates should pass through the hands of one man, who, for convenience, may be called the estimate clerk, although he should, in addition to clerical experience, have been through the works and have a good technical knowledge of the machinery, etc., with which he has to deal. Such a man is necessarily more expensive than an ordinary clerk, but the difference in salary is made up many times over in the avoidance of blunders with the losses which they entail.

All tenders should be made out on a special form, such as Form No. 10, and are preferably



TENDER.

Form N[illegible]

No....

M[illegible]

Dear Sir

In reply to your esteemed enquiry [illegible] ... [illegible] price for a Dynamo Electric Machine to work as .... [illegible] ... Type ... capable of developing ...... [illegible] ... Volts at a speed of ....
Revs. per Minute, in accordance with accompanying Specification and Tracing No..............will be as follows :—

Price of Machine alone..
Slide Rails
Third Bearing ..
[illegible]
,, Flywheel
[illegible]
Shunt.. .. .. ..

Price of Starting Switch ..
Regulating ,,
Reversing ,,
Combination Bedplate and
Coupling to Engine..

Packing..............................Carriage.. .Delivery within.. from date of Order

[illegible]

We trust to receive your Order, which shall receive our best attention and thanks, and remain, yours faithfully, of such a size that three can be copied on one page of an ordinary foolscap copying book. In this book the tenders only should be copied, and one tender only should be copied on each page. Thus two-thirds of each page are left blank after the tender has been copied, and this blank space allows for the copying of amended tenders or for the entering of special information. Each morning all inquiries are handed to the estimate clerk, who, on receiving them, turns to his press copy Tender Book and gives each inquiry its future Tender Number. Thus, suppose the Tender Book in use is No. 2, and the last page on which a tender is copied is 120, he will number the inquiry letters E2/121, E2 122, etc., and as he does so he will tick off the corresponding leaves in the book to indicate that they have been taken. The Tender Number should be quoted in all correspondence and other papers relating to it, so that at any future time the whole matter can be easily traced out if necessary.

An inquiry may be for a machine of standard pattern, a machine of special design, or it may be for a complete contract comprising various sizes of standard machines, special machines, erection at site with steam and water pipes and other accessories.

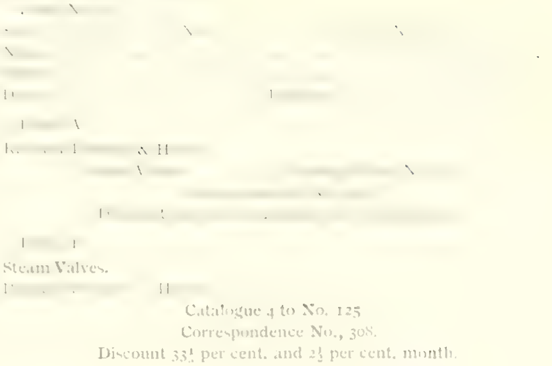
FREIGHT CHARGES.

For standard machines the clerk will keep a tabulated record of costs and net prices, and to these he will add such amount for packing, carriage, etc., as each case may demand. For the determination of railway charges, very convenient books may be obtained, which give for any town the railway rate for goods of any class to any other town served by the railways. Similar books may be obtained for dock charges. It is very important that these should be borne in mind in cases where goods are to be delivered F.O.B. Firms not accustomed to delivering F.O.B. very often assume that as railway charges include delivery (within a reasonable radius) to any factory or warehouse they also include delivery to a ship. This is not so; as the railway company only deliver to the dock and the dock company handle the goods and put them on board. Thus a sum must be added to the railway charge to allow for delivery F.O.B. The charges in different ports and for goods of different classes vary, but ought always to be kept in view.

DRAUGHTSMAN'S QUANTITIES.

Description.

CATALOGUE LABEL.



Steam Valves.

Catalogue 4 to No. 125

Correspondence No., 308.

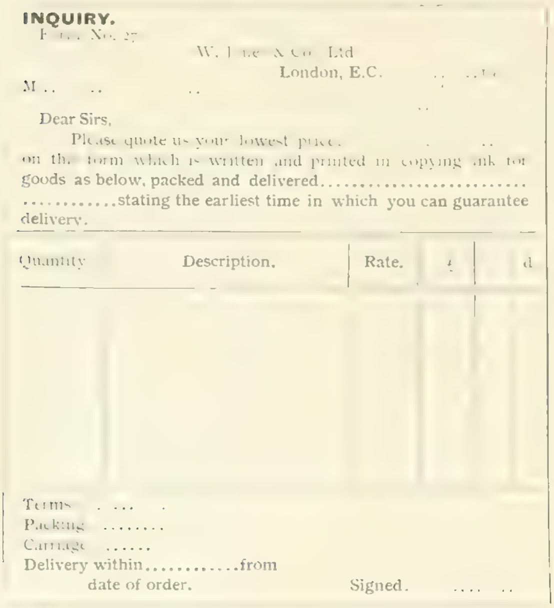
Discount 33⅓ per cent. and 2½ per cent. month.

Inquiries for special machines or complete contracts are handed to the chief draughtsman, who, instructed by the manager, prepares whatever drawings are necessary, and from these makes up the list of Quantities (Form No. 5). On this list, in addition to raw material, there are given the quantities of articles which may be purchased ready finished, such as lubricators, bolts and nuts, and other parts which it pays better to buy than to make.

THE FILING OF CATALOGUES.

Generally speaking, the prices of these may be taken from catalogues, so that a well-kept system of filing is very desirable. Catalogues as a rule are not well kept, the usual thing being to pile them on a shelf or stow them away in a drawer.

The system in use by the writer, and which he has also introduced recently in a large engineering works in the north, enables any catalogue to be found without any vexatious delay. The catalogues are kept in drawer boxes in which three sizes of drawer are used, one to take catalogues up to octavo, the second to take catalogues from octavo up to quarto, and the third to take sizes above quarto. Three books are kept, one for each size, in which the catalogues are entered and consecutive numbers given to them as they are received. To each catalogue is gummed a label (Form No. 78) on which are entered the particulars, which are also entered on two sets of cards, one under the names of the firms and the other under the subject matter.



INQUIRY.
Form No. 27
W. [illegible] & Co. Ltd
London, E.C. ..
M.. .. ..
..
Dear Sirs,
Please quote us your lowest price .. ..
on the form which is written and printed in copying ink for goods as below, packed and delivered........................
............stating the earliest time in which you can guarantee delivery.

Quantity	Description.	Rate.	£	d

Terms . ... .
Packing ....
Carriage ......
Delivery within............from date of order.
Signed. .... ..

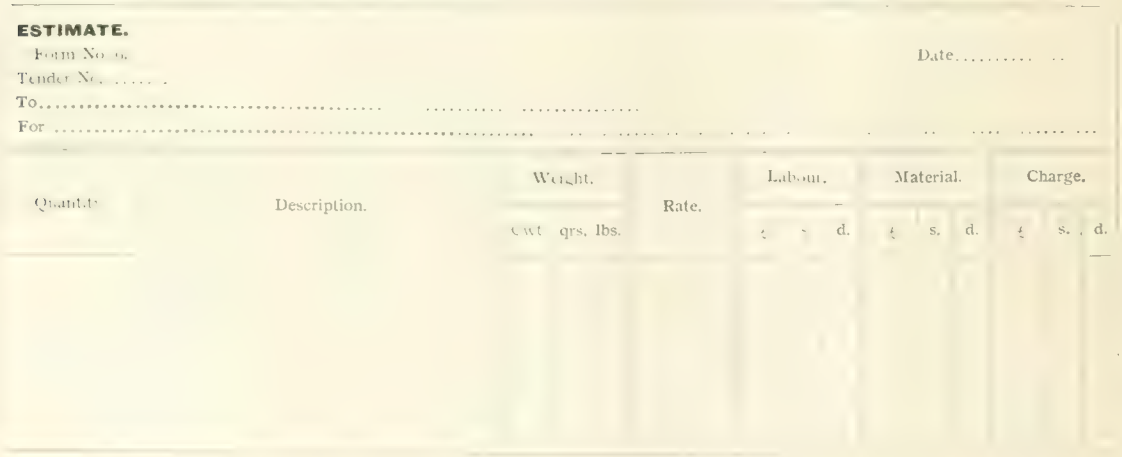
Examples A and B show the entries on two cards.

PREPARATION OF ESTIMATES.

Where special quotations have to be asked for, an Inquiry Form (No. 27) is sent out. These forms are filled up and returned by firms tendering, and are from time to time bound into books. The forms are numbered and a card index is kept of them the same as for catalogues.

Having ascertained prices for all the materials given on the list of quantities, the estimate clerk then enters up the material column of Form No. 9, adding a percentage to cover unbooked material. For the labour, the draughtsman prepares a list similar to Form No. 5, but with the columns headed with the different classes of labour and their rates of wages. This list, together with the drawings, goes to the different foremen, who fill in their estimates of the number of hours the different parts will take. Before going back to the estimate clerk these lists should be passed by the works manager, who may see fit to modify the foreman's figures. The estimate clerk then fills in the labour column of Form No. 9 and adds the percentage necessary to cover standing charges. Costs of packing, railway charges, dock charges (if any) are then added, and the estimate is totalled.

The manager or principals then decide what price shall be quoted, and the Tender Form (No. 10) is filled up, together with the necessary specification and drawings.



ESTIMATE.
Form No. 9.
Tender No. ......
To.. ....
For ....
Date.......... ..

Quantity	Description.	Weight.			Rate.	Labour.			Material.			Charge.		
		cwt	qrs.	lbs.		£	s.	d.	£	s.	d.	£	s.	d.

LOCOMOTIVE ENGINEERING NOTES.

Liquid-fuel burning Locomotives.

It is interesting to learn, upon what seems to be good authority, that Mr. R. J. Billinton, the locomotive superintendent of the London, Brighton and South Coast Railway, is about to try the experiment of burning liquid-fuel on some of the engines employed on that line. The system to be used is that invented by Mr. J. Holden, locomotive superintendent of the Great Eastern Railway. It has now been employed for many years on that railway, and has given results which must be characterised as entirely satisfactory. The use of liquid-fuel in locomotives is, of course, no novelty, having long been practised both in Russia and in America, where mineral oil is abundant and cheap. Mr. Holden's method, however, differs in some important respects from those hitherto employed in those countries where there is no uncertainty as to the permanence of ample supplies of the liquid-fuel. When Mr. Holden started the liquid-fuel movement in this country his object was simply to get rid of troublesome refuse, chiefly gas-tar. In the absence of any definite knowledge as to the amount of fuel that would be economically available, the engines, while able to burn liquid-fuel, had also to be fitted for coal consumption should the other combustible not be accessible. This principle has been adhered to in the case of all the liquid-fuel-burning locomotives of the Great Eastern Railway. Thus, should the liquid-fuel supplies at any time give out or become too costly, recourse can at once be had to coal without any alterations in the engines.

Method of Working.

In ordinary working the Holden engines burn liquid-fuel in association with solid combustibles, and not instead of them. The gas-tar or petroleum refuse is stored in tanks on the tender, and is sprayed into the firebox by means of roses on two pipes, through which the material is driven by a jet of steam, air being also admitted through an annular orifice in each rose. The hydro-carbon spray enters the firebox above a low coal fire in which there are numerous lumps of incandescent chalk. The spray is ignited, and while the engine is at work the firebox is filled with a clear, clean, pure white flame of great heating power, which the driver can regulate to greater or less intensity by adjusting two small thumbscrews. Thus the steam can be kept steadily at its most advantageous point, just below blowing-off mark during the whole length of a long non-stopping run, such as that from Liverpool Street to North Walsham—a distance of 131 miles, run at an average speed of about 50 miles an hour, and an actual working average of about 55. The convenience, cleanliness, and general advantageousness of the plan are indisputable.

Why not generally adopted?

It may fairly be asked: Why, if this plan be really so advantageous, has it not long ago been adopted by all the other railways? The answer is very simple. To use liquid-fuel engines, there must be ample supplies of liquid-fuel. Hitherto these have been wanting. The Great Eastern Railway practically absorbed all that could be obtained at remunerative rates. The locomotive superintendent of one of the leading Scottish lines wished to try the plan, but deemed it prudent first to ascertain whether, if he constructed the engines, he could get the fuel for them to burn. Finding, on enquiry, that the Great Eastern had secured all the cheap liquid-fuel available as far north as Glasgow itself, he reluctantly abandoned the idea. Lately, however, fresh sources of supply having been discovered, several railways have begun to use liquid-fuel, and the experiment will be tried on the London, Brighton and South Coast, as well as on the South Eastern and Chatham, and on the Metropolitan. Of its success there can be no doubt at all. Absolute proof has been afforded that Mr. Holden's system is equal to all requirements if adequately managed. Therefore, should it fail in any other case, the fault will be attributable, not to the system, but to its local working. However, no such failure need be anticipated, and the increasing use of liquid-fuel will do much to obviate the nuisance caused by railway smoke and sparks.

Compound Locomotives.

Another valuable improvement that of compounding, for locomotives, has recently made a fresh step forward in England. For many months rumour was busy with a report to the effect that at Derby—that railway "home of mystery"—a new type of compound locomotive had been designed by Mr. S. W. Johnson, the able locomotive superintendent of the Midland Railway, and that two pioneer engines of this class had been built. This report proves to be correct, and Nos. 2631 and 2632 have not only left the Derby shops, but have actively begun work, one taking daily the 10.5 a.m. train from Leeds and the other the 3.55 p.m. from Carlisle. The two engines are practically identical, save that one has plain copper tubes giving 1,598 square feet of tube heating-surface, while the other has the Serve or ribbed tubes, which give 1,720 square feet of surface. Each has 150 square feet of heating surface in the firebox, 26 square feet of grate area, and works at a boiler pressure of 195 lbs. of steam per square inch. Mr. Johnson appears to have adopted in a large measure the same arrangement of cylinders, etc., as that of No. 1619 on the North-Eastern Railway, excepting that the piston stroke is 26 in., both with the high-pressure and the low-pressure cylinders. There is only one high-pressure cylinder, which is placed inside the frames and drives the leading coupled axle by a single-throw crank. There are two low-pressure cylinders, each 21 in. in diameter, placed outside. They drive the same pair of wheels. By a special arrangement of the valves it is provided that although the steam pressure in the boiler may be 195 lbs. per square foot, the pistons shall never be forced to bear a severer strain than that which would ordinarily be experienced at a pressure of 170 lbs. in the boiler, which is that employed in many Midland engines. The pressure in the low-pressure cylinders is ordinarily 40 lbs. to 60 lbs., but this can be reinforced in case of need by the admission of auxiliary steam from the boiler through a special valve. Stephenson's link-motion is used to work the valves, and the reversing gear can be applied at will either to high-pressure or low-pressure cylinders separately, or to both together with the same handle. Special devices are employed to minimise back pressure.

Dimensions of New Midland Engines.

The leading dimensions of the new Midland compound engines are: Diameter of driving and trailing wheels coupled, 7 ft.; bogie wheels, 3 ft. 6 in.; high-pressure cylinder (1), 19 in. by 26 in.; low-pressure cylinders (2), 21 in. by 26 in.; total heating surface (plain tubes), 1,598 square feet (Serve tubes), 1,720 square feet; diameter of boiler barrel (inside), 4 ft. 8 in.; length of boiler 11 ft. 7 in.; height of boiler-centre above rails, 8 ft. 6 in.; grate area, 26 square feet; steam pressure, 195 lbs. Weight of engine in working order: On bogie wheels, 20½ tons; on driving wheels, 19½ tons; on trailing wheels, 19½ tons; total, 59½ tons. Tender (on two four-wheel bogies) loaded, 52½ tons; total of engine and tender, 112 tons. The new engines appear to be working very well and to be giving good results. It will be observed that Mr. Johnson, in his new three-cylinder compounds, exactly reverses Mr.

Webb's three-cylinder practice, as did Mr. Worsdell with No. 1619 on the North-Eastern Railway. That is to say, whereas Mr. Webb has two high-pressure cylinders outside and one low-pressure cylinder inside, Mr. Johnson and Mr. Worsdell have one high-pressure cylinder inside and two low-pressure cylinders outside. Experience alone can decide which of the two plans is preferable.

Two, three, or four-cylinder Compounds.

It will also be interesting to note the comparative working of this new class of three-cylinder compounds as against the performance of the four-cylinder types on the one hand, and the two-cylinder class on the other. With such able and eminent locomotive engineers as Messrs. du Bousquet, de Glehn, Mallet, Görlsdorff, von Borries, Webb, Worsdell, Vauclain, and now Mr. Johnson, all testing the compound system as applied to locomotives, some definite results must surely be reached at no very distant date. The point is a vital one in locomotive practice, and it should be settled definitely whether or not compound locomotives are advantageous on the score of economy and efficiency as compared with non-compound engines. If so, it remains to be proved which method is preferable—the two-cylinder, three-cylinder, or four-cylinder and of the several variants of these, which is the best. Experiments have been going on for very nearly twenty years in this country alone, and it is surely time that the question was solved decisively once and for all, as it has been in the case of steamships.

Another New Nord Tank Engine.

A large number of M. du Bousquet's new express tank engines for fast suburban traffic are now at work on the Chemin de Fer du Nord, and are doing extremely well. They run on twelve wheels, the two middle pairs being coupled to have both leading and trailing four-wheel bogies. Their boilers are unusually high-pitched for tank engines. They have 5 ft. 5 in. coupled wheels, outside cylinders 17 in. by $23\frac{1}{2}$ in., and 1,395 square feet of heating surface. The type is a remarkably good and efficient one for that class of service.

"Atlantic" type Engine for Orleans Railway.

Some large express engines of the "Atlantic" type and on M. de Glehn's four-cylinder compound principle, have been designed by M. Solacroup, the eminent chief mechanical engineer of the Paris-Orleans Railway, for the heavy express service of that line, and are now in course of construction. It is understood that they will be very similar to those referred to above in the case of the Chemin de Fer du Nord.

MODERN PRACTICE IN MILLING AND AMALGAMATING.

BY

EDGAR SMART, A.M.I.C.E.

In the preceding Article the author discussed separately the various conditions necessary to secure a maximum of efficiency in stamping mills. The present Article deals more particularly with amalgamating, and institutes an interesting comparison between the respective methods.

II.

AMALGAMATION.

GOLD ores have been generally divided in a vague sort of way into two classes, termed free milling and refractory ores respectively. That is to say, when a fair proportion of the value contained in any auriferous material can be readily amalgamated with quicksilver, it is termed a free milling ore. At one time it was considered that gold which could not be recovered in this way was in chemical combination with other elements, such as sulphur. Nowadays it is generally admitted that, with the exception of tellurides of gold, practically all known ores contain their gold in a free or uncombined state, and that amalgamation difficulties are due to one or the other of the following causes :—

1. The sickening of the quicksilver by certain mineral constituents present in the gangue, antimony sulphide being the most troublesome in this respect, although good work is done in Australia on ores containing up to 1 per cent. of this mineral.

2. The gold existing as a fine deposit upon and in the crystals of iron pyrites, so that it cannot be retained by the quicksilver, but is carried away with the particles of pyrites.

3. The particles of gold being so fine that they remain mixed with the pulp, and do not come in contact with the quicksilver.

In the first case, only a part of the gold can be caught by prolonged pounding in the mortar box, or by some equivalent method, and this is accompanied by a large loss of quicksilver and amalgam. In the second case, amalgamation in grinding pans is effective, but not economical, owing to the large cost for power and the loss of mercury, which latter is not so great, however, as in the first case. In the third case, amalgamation is quite unsuitable, and in modern practice no attempt is made in the last two cases to catch the gold in the mill, because, as already mentioned, more successful methods are now available, and experience has shown that the percentage of gold recoverable from any ore by the best amalgamation methods depends almost entirely upon the relative amounts of coarse and fine gold present, and upon the physical conditions above mentioned.

Any comparisons, therefore, made upon the basis of percentage extraction, between one man's work and that of another, or between one method and another, may be utterly misleading, unless the same kind of material is being dealt with in both cases. Thus, for instance, on the Bendigo goldfields, where the treatment process consists almost universally of crushing and amalgamating, followed only by concentration on large canvas tables, the tailings from this simple treatment average about 1½ dwts. to the ton over the whole district, the maximum value for any large quantity being about 2 dwts. According to the official returns the average recovery on over 2,000,000 tons was

8 dwts. of bullion, equal probably to 7½ dwts. of fine gold. On the Rand goldfields, at the time when only amalgamation and concentration were used for gold recovery, the tailings from ore of a similar grade would average at least 2½ dwts. per ton, but it would certainly be absurd to infer from this difference of results that the Rand millmen at that time were inferior to their brethren in Bendigo.

The next example illustrates the fact that with a given ore, the percentage of recovery by amalgamation is independent of the value. In Gippsland, Victoria, in a mill catching 1 oz. of gold per ton the tailings contained 2 dwts. In another mill, working ore from the same line of reef, the recovery was 2 ozs., and the loss in the tailings was 4 dwts., so that the percentage was the same in both cases.

It must not be supposed that the moral of all this is that skill and care are unnecessary in the amalgamation process; on the contrary, they are essential to success. But it is necessary to get rid of the idea, so prevalent in some parts of the world, that a loss of gold in tailings is a certain proof that the battery work is inefficient. If this were merely a personal matter between mine owners and employes it would not be necessary to elaborate the point in a technical consideration of the subject; but it is a matter which in some cases causes the total loss of gold which might be recovered by other means. In fact, where this opinion prevails, the millman who (from his point of view) is cursed with rich tailings dare not face the fact and recommend the application of cyanide or other additional treatment; but he endeavours by any means possible to make it appear that his tailings are poor. One instance will forcibly illustrate the fact that this feeling does really exist. On one occasion a sampler was sent to take samples of tailings pulp below the canvas tables of a certain mill, say in Australasia, with a view to purchasing the current tailings. The manager who represented the sellers had all his canvas tables carefully cleaned up before the samples were taken, so that they should be working at their maximum efficiency, and that therefore, the tailings samples should be as poor as possible. Naturally, the representative of the buyers made no objection, but the shareholders in the company might have done so very reasonably.

There is no doubt that the recognition of the natural limitations of the amalgamation process is not only necessary for the determination of the best treatment of any given ore, but it also conduces to the proper working of the mill. In Johannesburg it cleared the way for the improvements which have so largely increased the output of the mills, without decreasing their efficiency in catching gold.

THE USE OF MERCURY.

The whole process depends on the one fundamental fact that clean gold readily amalgamates with clean mercury when the two are brought into actual contact. It is not surprising, therefore, that many attempts have been made to achieve this result by means of baffle plates, riffles, shaking tables, and the like, the leading idea in all such apparatus being to *disturb* the flow of pulp as much as possible, and to produce currents and eddies which should dash the particles of gold against amalgamated surfaces. Probably, every beginner in the art has been the proud possessor of some such idea at one time or another; and only those are truly happy who have not spent their own money in demonstrating its inutility in practical work.

The other point of view is to disturb the pulp as little as possible, and to allow it to flow so evenly and steadily that each particle of gold can gradually settle down through the pulp till it finally comes naturally and quietly into contact with the amalgamated plate beneath it, and is thereby caught. Of course, as the pulp is delivered from the mortar box in the form of a series of splashes superimposed upon a regular flow of water, an absolutely even flow cannot be expected, but, at all events, by avoiding artificial means for disturbing the flow, better results can be obtained than otherwise. The credit of introducing on the Rand the long unbroken surfaces of amalgamated plate instead of several short lengths with drops or riffles between them is due to the well-known mining engineer, Hennen Jennings, who demonstrated the advantage of the unbroken surface by means of simultaneous experiments on the two systems. The usual arrangement now is a lip plate, which projects a few inches immediately below the screen frame, and delivers the pulp on to a splash plate, which is inclined downwards towards the screen, and projects under the lip plate. From the splash plate the pulp is delivered to the head of the table, and thence flows uninterruptedly along until it reaches the mercury well at the foot of the table.

THE FUNCTION OF COPPER PLATES.

It is obvious that if the particles were brought into contact with the clean surface of a pool of liquid quicksilver they would be amalgamated, but the amalgam, being heavier than the mercury, would fall to the bottom, and a surface of mercury only would be available for catching more gold, while experience has shown that a surface of gold amalgam keeps cleaner and in better condition than the quicksilver alone. Therefore, by using a mercury film on a metal plate, the surface soon becomes covered with a layer of gold amalgam. There are other self-evident objections to the use of liquid mercury —its cost, owing to the quantity required to form a large continuous surface, the loss by attrition caused by particles of ore, and the impossibility of having an inclined surface. It is only necessary to mention these well-known facts, because they point to the true functions of the copper plate—namely, that it allows of the formation of an extended surface with a small quantity of quicksilver, that it holds the latter in place and keeps the amalgam on the surface, where it is required to catch more gold. In fact, it has the same duty as the glass in a photographic plate ; it serves as a support for the active film upon it.

A man standing on the bank of a river holding on to a tree with one hand and reaching out with the other for floating sticks illustrates the position of the quicksilver. So long as both hands perform their function the work is satisfactory ; if either fails, then either the sticks are lost or sticks and man together. Just in the same way the quicksilver is required to seize the particles of gold and to hold on to the plate at the same time. The one thing necessary to enable it to do both satisfactorily is cleanliness.

In the first place, the copper plate must be absolutely clean before being amalgamated, so that the film of quicksilver shall cover the whole of its surface. This cleaning is usually done by scouring with sand, and afterwards with wood ashes, or with caustic alkalies, to get rid of the two most potent enemies of the quicksilver—namely, grease and films of oxide on the metal Perhaps the latest method of amalgamating the plate after it has been cleaned is to rub it over with a solution of potassium cyanide in which quicksilver has been dissolved. As it is rubbed with this solution its surface becomes gradually whitened by a very thin deposit of the mercury, after which either mercury or amalgam of gold or silver will adhere to the surface when rubbed on. But this is only the first stage of preparation, for as soon as the plate is in use, the soluble sulphates and other bodies in the ore form coloured patches, generally greenish, on the copper, and these patches will not retain the film of quicksilver. This is the first matter that needs the attention of the amalgamator, who must constantly clean off these greenish films and rub in amalgam until the whole plate gets into good condition. It is often assumed that this improvement is entirely due to the gradual increase of gold amalgam on the surface, and this is no doubt true to a large extent, as evidenced by the fact that when crushing rich ore the plates get into order more quickly than with poor stuff. But it is also probable that in the first place only the very outer surface of the copper becomes coated with quicksilver, and that the coloured films, caused by oxidation or other similar action, begin in the pores of the metal and gradually extend under the mercury, which can then no longer hold on to the plate. As the amalgamation of the copper penetrates into the thickness of the plate and the surface pores at least are amalgamated, it becomes increasingly difficult for the battery water to come into actual contact with metallic copper, and consequently no objectionable films can be formed. With care and patience new plates can be got into good condition in a couple of weeks. If might be well asked whether any great improvements have been made in recent years, or indeed whether any advance is necessary or possible in conducting operations so simple as those just described. The chief gain during the last few years has been the application of plain common sense to the art of amalgamation and the consequent disappearance of the professional "plate-setter," who like a Kaffir witch-finder was surrounded by a halo of mystery, and was supposed to carry a heavy burden of carefully concealed special knowledge, enabling him, by proper nostrums, possibly mixed with spells and incantations, to induce the plates to perform their office.

SILVER-PLATED COPPER.

The use of electro-silvered copper plates for batteries has been strongly advocated by some authorities and as strongly condemned by others. As usual in such cases the truth seems to be situated in the equatorial regions half-way between the two opposite poles of personal opinion. It is a reasonable supposition, in consequence of the wide range of variations in the constituents of ores, that the battery water in some instances may tarnish copper more readily than silver, and that in other cases it may have exactly the opposite effect.

This is at all events a possible explanation of some of the differences of opinion which exist on this matter. The silvered plate certainly has the advantage that it can be more easily coated with the mercury in the first place, and that when this operation has been performed, the whole surface is then covered with silver amalgam, which is less easily tarnished than a plain mercury surface. Therefore it may safely be said that generally in places where inferior labour has to be employed, the use of electro-silvered plates will prevent loss of gold during the first few weeks of the operations, and that only in some cases, as suggested above, could they possibly do any harm. But when the plate is well amalgamated all over, when after a few months' work this amalgamation has penetrated into the plate and a quantity of gold amalgam has been retained upon it, and when much of the silver must have been removed with the gold in the periodical cleaning up, it is scarcely reasonable to suppose that the original plating can have any beneficial effect.

The latest advocate for silver-plated copper, Mr. Edward Halse, makes out an excellent case for it by showing that at a mine in Columbia a considerably larger percentage of gold was caught on the plates, and a correspondingly smaller percentage on the blankets when silvered plates were substituted for plain copper ones,* and that this increase was a permanent one. But he then says "it should be mentioned here that much more mercury was used with the plain copper than with the silvered plates, which accounts for a good deal of the amalgam found in the mercury traps and on the blankets in the former." Now this appears to be the most important sentence in the whole paper, for as the remaining conditions were fairly constant, then if the right quantity of mercury was used with the silvered plate it follows that an excessive amount must have been used previously with the plain copper, with the natural result indicated. In fact this one sentence explains the whole of the results in such a simple and convincing manner, that the case for the silvered plates so ably advanced seems to be thereby put out of court. It is quite in accordance with experience that excess of mercury will carry amalgam off the plates on to the blankets below them, while it is hard to understand how a single addition of one ounce of silver per square foot of plate can have a greater permanent effect than the many ounces of gold caught from time to time during the continued working of either kind of plate.

Mr. G. E. Collings, on the same occasion, gave results of two sets of comparative tests which showed a greater return in *amalgam* in each case from silvered copper than from plain copper, but the yield in *melted gold* was in one set greater and in the other set less from the silvered plates. In other experiments between new and old silvered plates the results were equal. So the conclusion from the evidence seems to be that while silver-plating may be of advantage at first, it makes no practical difference after a few months' operations.

INSIDE AMALGAMATION.

This is another question upon which widely different views are held, principally because each man favours the practice which gives the best result with the kind of ore with which he is most familiar. When the gold is nuggety in character it is sure to stay in the boxes, whether mercury be added or not, but the addition of the mercury rather facilitates the collection of the gold when the mortar boxes are cleaned out, and it is therefore generally used with very coarse gold and sometimes inside plates are used.

When the gold is fine enough to pass the screens as quickly as it is liberated from the gangue it is a matter of less importance as to whether inside plates are used. The main argument in favour of them is that it is wise to catch the gold as soon as possible, and that back and front plates receive nearly all that part of the splash which does not strike the screen, so that every particle of gold is amalgamated at the earliest possible opportunity. There is one necessary precaution which is not lost sight of at the present day, namely, that the mercury necessary for the inside plates must be added in very small quantities at frequent intervals, in order that the outside plates shall not at any time receive an excess from the mortar boxes.

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* [illegible]

With very fine gold in clean ores good work is done both with and without amalgamation in the mortar boxes.

QUANTITY OF QUICKSILVER.

The amount of quicksilver which must be supplied to the plates either directly or through the boxes depends not only upon the quantity of gold, but also upon the size of the particles which have to be caught. The amalgam on the plates cannot be expected to carry more gold than the proportion found in the squeezed amalgam as prepared for retorting; in fact, it must necessarily carry less. This squeezed amalgam contains about 25 per cent. of gold when very fine, and up to, say, 70 per cent. in the case of very coarse gold. These figures then will give the absolute minimum quantity of mercury which must be added per ounce of gold caught. That is to say, with the finest gold at least 3 ozs. of quicksilver should be added to the plates for each ounce of gold caught upon them, while for coarse gold one-sixth of this would be the minimum quantity. Of course, in practice more than this is added, and with inside plates much more, because part of it settles down and collects in the boxes. The safest guide is the condition of the plates. When too much is given it can be seen trickling slowly in little streams along the plate, and, although most of this excess is caught in the mercury trap at the foot of the table, some of it is liable to be floured and lost. And loss of quicksilver from the plates means also loss of fine gold. If, on the other hand, too little is given, the gold amalgam on the plates becomes dry and friable, and is liable to be carried away by the attrition of the grains of sand. Amalgam in fit condition to catch gold should appear *moist* and *granular*, but not wet.

WATER SUPPLY.

The water used in the battery may be considered in the first place as the vehicle by means of which the crushed ore is transferred from the mortar box and carried over the plates; and, secondly, as the medium through which the gold can settle down on to the plates while the gangue particles having less specific gravity are carried forward by the current. As regards the first function, the quantity required will necessarily vary with the nature of the ore, but in any given case the effect of altering the quantity can be ascertained by a series of grading tests on the pulp produced.

The following example of such tests is taken from a paper read by Mr. John McConnell, of New Zealand, before the Institution of Mining and Metallurgy.* It is particularly interesting as showing what occurs when very fine screens and very limited quantities of water are used, as well as illustrating the method of testing.

1. Crushing with 2 tons of water per ton of ore :—

Sand retained on	60-mesh screen	3 p.c.	
„ „	90-	„	21 „
„ passed through	90-	„	76

2. Crushing with 4 tons of water per ton of ore :—

Sand retained on	60-mesh screen	13·5 p.c.	
„ „	90-	„	20·5
„ passed through	90-		66·0

As these tests were made for a special object, no results are given with larger quantities of water, but they show that the increase of water from 2 tons to 4 tons reduces the amount of very fine stuff by 10 per cent. The next example shows the result of crushing Rand ore with about 9 tons of water per ton of ore. As the material is different and the battery screen was coarser, it cannot be rigidly compared with the figures given above. The test was made by Mr. A. F. Crosse, of Johannesburg,† and may be taken as typical of the results obtained there.

Sand retained on	30-mesh screen	6·25 p.c.	
	60-	„	20·30 „
	90-	„	30·00 „
	120-	„	9·25 „
„ passed through	120-		[illegible] „

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* Vol. VII [illegible]

† [illegible] vol. i., p. 325.

Returning to the second function of the water, namely, as a medium for the settlement of the gold, it is clear that the slower the velocity of the stream the more rapidly can the settlement take place; but, on the other hand, a sufficient state of flow must be maintained to just carry off the heaviest particles of the gangue, and it is this limiting velocity which is aimed at in practice. The required velocity is quite a separate question from the quantity of water, and it is attained by the inclination given to the tables. Thus, with a gangue of clean quartz, finely crushed, a slope of 1 in. per foot is sufficient. With iron pyrites present, and with 700-mesh screens, 1½ in. per foot is used; and with ores containing heavy minerals, such as galena, 2½ in. per foot is required. In most cases a few particles of mineral or of black sand may be seen clinging to the surface of the amalgam. Having determined the velocity, the quantity of water supplied must then be sufficient to keep the plates well covered; and where the quantity passing through the boxes is not enough for this purpose, it is usual to provide an extra supply at the head of the plates outside the boxes. An excess of water does not cause a proportional increase in the rate of flow, and up to a certain point the settlement of the gold is probably assisted by the dilution of the pulp. Up to the present time the tendency has been towards liberality in water supply; but it is possible that the New Zealand practice of crushing with limited quantities of cyanide solution may be followed in other countries where the gold is in a similarly fine condition.

SAVING WATER

There are many places where the quantity of water available is strictly limited, and where every care has consequently to be taken to preserve it for use over and over again. The statement that a mill requires 6¼ gallons per stamp per minute does not look very large; but when the total quantity used in a year is reckoned up and compared with the rainfall, the result is somewhat startling. As an example, take a 100-stamp mill, crushing 500 tons of ore with 4,500 tons of water daily = 144,000 cubic feet. At 360 days per annum, this is 51,840,000 cubic feet, which is equal to one inch of rainfall over 22·3 square miles of country.

The most obvious means for saving water is the provision of settling dams of large capacity for the clarification of the water, these being preferably situated below the mill, so that clear water only has to be passed through the pumps.

Settling boxes, with pointed or flat bottoms, and also small settling dams, shovelled empty at intervals, have been often used for this purpose with some success. But in recent years on the Rand goldfields, the methods primarily designed for the precipitation of the battery, sands and slimes for immediate further treatment have led to the development of an excellent system of saving and clarifying water, so that it can at once be returned to the mill. Briefly described, this includes first, the elimination of coarse sand in spitzlutten; secondly, the separation of fine sand in overflow tanks; thirdly, the addition of quicklime; and fourthly, the settlement of the slime in a large spitzkasten so completely that the water is at once fit to use again. At the Matterhorn Mine, in America, a similiar system, on a small scale and without the use of lime, was successfully employed,* and 75 per cent. to 80 per cent. of the battery was returned for re-use.

The following sizes are found suitable for the spitzkasten with Johannesburg ore when lime is used. Width 0·55 foot for each cubic foot of pulp delivered per minute, and the length from two-thirds to three-quarters of the width. In order to avoid an excessive depth the spitzkasten are divided into a number of divisions, each being about 5 ft. square, and each having a separate pointed bottom and outlet. At the Matterhorn Mine above mentioned, a spitzkasten, 6 ft. wide and 10 ft. long, was used for each five stamps, the allowance being 3·33 ft. of width for each cubit foot of pulp per minute; that is, six times the width allowed in Johannesburg. The difference is apparently due to two causes: First, the absence of lime in the Matterhorn case, and, secondly, the extreme fineness of the pulp, as evidenced by the fact that 79 per cent. of the whole product passed through a 100-mesh screen. The two cases may be taken as representing the extreme limits of practice in either direction in connection with the settlement of slime.

MILLING v. AMALGAMATING.

Having now considered separately the most important points connected with milling and

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[illegible]

amalgamation, a few words may be said on the question raised in the early part of this article as to whether a high stamp duty necessarily involves a loss of gold which might otherwise be caught on the plates. Where the gold is coarse it settles so readily in the boxes and on the plates that it cannot be imagined for a moment that any rate of crushing practically possible could affect the percentage recovered by amalgamation. So far as the plates are concerned, an increase of output must result in one of two things—either the pulp will carry more solid matter per unit of volume if the water supply remains constant, or there will be a greater depth of pulp on the plates if the water supply is increased. In either case it is possible to suppose that a limit may be reached in time which will interfere with the rapid settlement of very fine gold on the surface of the plates; but up to the highest stamp duty yet attained this effect is likely to be negligible. Owing to variations in ores and in other conditions, it is difficult to get figures which can be compared with strict fairness, but the following tables, compiled from the annual reports of the two Johannesburg companies, bear out the above statement:—

TABLE III. RETURNS FROM CROWN REEF GOLD MINING COMPANY.

Year.	Tonnage.	Tons per stamp per 24 hours.	Percentage of Ore value recovered in Mill
1895-6	200,442	5·110	52·901
1896-7	199,898	4·795	50·010
1897-8	185,179	[illegible]	57·806
1898-9	202,456	4·908	56·420
1900	12,269	5·440	

TABLE IV. RETURNS FROM SIMMER AND JACK PROPRIETARY MINES, LTD.

Year.	Tonnage.	Tons per stamp per 24 hours.	Gold caught in Mill. Dwts. per ton.
1897	123,325	4·37	5·83
	35,740	4·80	6·25
1898	70,810	4·47	5·08
„	103,440	5·02	6·13
„	115,000	5·27	6·35
	123,540	5·38	6·57
1899	130,430	5·37	6·73
„	133,710	5·47	6·35
	128,639	[illegible]	5·61

It will be observed that neither table shows any indication of loss of gold as a consequence of increased stamp duty.

A RECENT RAND MILL.

The mill of the Lancaster West G. M. Company commenced crushing only a few months before the war, and will serve as an example of the very latest Johannesburg practice. The following particulars are obtained from the company's annual report:—

The ore breakers are situated at the back of the mill below the ground level, so that the ore can be conveniently delivered to them in trucks from bins at the headgear. The broken ore passes into bins below the breakers, and thence is carried to the top of the mill by a Reedy elevator. There are two crushers of the Blake-Marsden type, 24 in. by 14 in. The mill is provided with exceptionally large ore bins, their capacity being equal to four and a half days' crushing. There are forty stamps, weighing 1,250 lbs. each. The engine, supplied by the Erste Brunner Maechinen Fabrik, is a compound tandem with high-pressure cylinder of 18¾ in. diameter, low-pressure cylinder, 30 in. diameter, and with a 3 ft. stroke. It is estimated to drive 100 stamps if necessary. The rock breakers are driven by a similar engine, whose dimensions are 15¾ in., 25⅝ in., and 31½ in., respectively. Surface condensers are used, and water-tube boilers supply the steam.

This mill started towards the end of May, 1899, and was stopped in the middle of October of the same year, on account of the then impending war, and during this short period it crushed 31,730 tons of ore in 123·3 days, actual running time, which works out at 6·43 tons per stamp per day.

COST OF MILLING.

A great deal might be said on this section of the subject, but the following miscellaneous collection of official figures will sufficiently illustrate the great variation of working cost, caused by local conditions to some extent, but which of course are largely due to the scale upon which operations are conducted. The examples have been taken almost at random from the enormous amount of such useful information to be found in the reports of Chambers of Mines and Mining Companies. Where possible, the tonnage crushed is inserted, as well as the cost, together with other information which affects the cost :—

1. Guests Gold Mine, Mt. Morgan, W.A. June, 1900 :—

Crushed 695 tons for 343 ozs. bullion.
Cost of milling, including water supply, 14s. per ton.

2. Lady Loch, W.A. June, 1900 :—
Crushed 750 tons for 602 ozs. bullion.
Cost of milling, 7s. 8d. per ton.

3. Hill End, W.A. May, 1900 :—
Crushed 770 tons for 642 ozs. bullion.
Cost of milling, 9s. 4d. per ton.

4. Vale of Coolgardie. June, 1900 :—
Crushed 1,040 tons for 601 ozs. bullion.
Per stamp per 24 hours, 3·6 tons.
Cost of milling, 8s. 10d.

5. Norseman Gold Mines, W.A. June, 1900 :—

Crushed 2,244 tons for 785 ozs. bullion.
Per stamp per 24 hours, 3·35 tons.
Cost of milling, 6s. 3d.

6. Sons of Gwalia, Leonora district, W.A. Average of nine months in 1900, during which 33,812 tons were crushed :—

	s.	d.
Ore transport	0	10·08
Milling	5	0·21
Maintenance	0	5·00
General charges ...	0	8·23
Total ...	7	1·02

7. Wentworth Mine, New South Wales. Year 1898, during which 1,898 tons were crushed :—

	s.	d.
Labour ...	0	10·2
Fuel	1	1·6
Stores	0	2·0
Maintenance ...	1	0·5
Management	0	3·7
Total ...	3	6

8. Lancaster West Mine, Johannesburg, with mill described above :—

	s.	d.
Sorting, tramming and breaking	1	2·19
Milling	2	3·86
Total ...	3	6·05

9. Robinson Mine, Johannesburg, December, 1901 (during the war) :—
Crushed, 8,036 tons.
Milling, including maintenance, 2s. 11·12d.
Concentrating, including maintenance, 5·57d.

10. Crown Reef Mine, Johannesburg, 1895 to 1899 :—

Year	[illegible]	[illegible]	[illegible]	1898-9.
Tons crushed	[illegible]	[illegible]	[illegible]	202,456
	s. d.	s. d.	s. d.	s. d.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0 8·285	0 6·617
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Maintenance	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	0 0·706	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0 0·720	0 0·894
Totals ...	[illegible]	[illegible]	[illegible]	[illegible]

The uniformity during so many years of the total costs in this last example, and also of the individual items, may be noted as an indication of the perfect control which can be maintained over an enormous expenditure by means of the detailed accounts and systematic analyses of costs which are characteristic of Rand mining. Owing to the exceptionally complete technical information published by the management of this company the analysis of the costs for 1898-9 can also be given in the following way :—

	s.	d.
European wages	0	8·914
Kaffir wages, including food	0	2·110
Materials and tools...	0	11·280
Fuel ...	0	7·356
Lighting ...	0	0·894
Workshops	0	3·252
Total, as above ...	2	9·806

Considering the high cost of all white labour and of materials in Johannesburg, and that the Kaffir labour has very little effect on the cost of the mill work, the above figures, which are fairly representative of the whole district, show how cheaply the work can be carried on under the beneficent combination of large tonnage and efficient management.

WORKSHOP PRACTICE

A RÉSUMÉ OF MACHINE TOOLS, CRANES, AND FOUNDRY MATTERS FOR THE MONTH.

A LATHE FOR 4-INCH BAR WORK.

A NEW lathe has been designed by Clark's Engineering and Machine Tool Company, Ltd., of Luton, for exceptionally heavy bar work. The hollow spindle is bored out to 4⅛ in. diameter, and the lathe is capable of reducing a 4-in. bar to 1½ in. diameter at one cut. One of similar design is made for 3-in. bars, and the firm is about to bring out one for dealing with 6 in. stock. Lathes of such capacity and power as these render much bar work less costly than machined forgings.

The general build of the lathe is English, modified by the hollow spindle and the unusually massive proportions. Besides heavy bar work it will do all that an ordinary sliding, surfacing, and screw cutting lathe is capable of performing. It is driven by a 4-in. belt, and is back geared, the gears being encased. The back shaft has three changes of speed for sliding and surfacing by differential gears, which are put into operation by a lever in front, below the headstock, and without stopping the machine. The common English type of saddle is employed, but it has two rests. The one in front carries four tools, and can be revolved to bring either tool into operation, and a stop is fitted for transverse adjustment. The other rest at the back of the cross slide carries cutting-off or forming tools. This can be removed, and a screwing die head put in its place for screwing the ends of pins, etc., up to 2½ in. diameter.

The headstock caps are set at an angle with the base, so reducing the strain on the studs, and improving the adjustment sideways, instead of up and down only. A hinged bar support is seen at the rear, and a cupboard for tools under the head. Ordinary forged tools are used. The lead screw is protected by a long cap ; a waste oil tray lies below the bed ; the ribs of the loose poppet are cut away to clear the handle of the slide rest, and the change gears are massive, harmonising thus with the general design. Such a lathe as this should be an acquisition in those shops where there is not a sufficient volume of work for automatics or heavy turret lathes.

HIGH SPEED TOOL STEELS.

Unusual rivalry is being manifested in the production of high speed tool steels, following the Taylor-White, shown in operation at Vincennes in 1900, and several firms now offer such steels. A Manchester committee has made arrangements for the testing of samples of these, offered by eight local firms. Sir W. G. Armstrong, Whitworth, and Co. have brought out a steel of their own brand which they claim has beaten the Taylor-White by 25 per cent. in cutting speed, though the cutting was continued for more than twice the length of time. A tool has been run for forty-five minutes at 150 ft. per minute, with a $\frac{3}{16}$ in. cut, and $\frac{1}{16}$ in. traverse. A Sheffield firm has an air-hardened steel which has tooled a hard cast steel pump plunger at 80 ft. a minute, lasting for forty minutes without injury to the tool, in this case with a cut of ⅜ and $\frac{3}{16}$ in. feed. Other severe tests have been given in which the tools have retained their edges. We shall hear more of these high speed steels. A result is that stiff lathes have to be manufactured to endure the higher stresses imposed by such severe cutting.

DRILLING EXTRAORDINARY.

The great interest which attaches to any reported increase in the amount of metal removed in a given time by cutting tools, illustrates the great importance of this subject in competitive production. The new machines and tools give an enormous output compared with the older ones. But the difference between some of the modern kinds and the older ones is not much less than that between these and hand labour. This fact has received illustration lately in two directions, the work of twist drills, and in the high speed steels, just instanced.

The Morse table of speeds for drills is generally accepted as the best standard for the use of up-to-date shops, and higher than the practice of the older shops. But the Bickford Drill and Tool Company have recently been exceeding these performances, employing feeds so coarse that the marvel seems that the drills have not been broken. The firm has, in several experiments, tested the drills to destruction; but in some instances the experiments were stopped by the slipping of the belt. The Morse table recommends for ¼-in. drills a feed of ·005 in. per revolution; for a ½ in. drill ·007 in. per revolution. The Bickford practice gives a feed of ·025 in. for drills from ¼ to ½-in. For ¾-in. drills the Morse feed is ·010 in. per revolution; the Bickford feed for ½-in. to 1-in. drills is ·035 in. per revolution, and these differences are paralleled in other sizes.

Tests made to destruction, on a ¼-in. drill, drilling in cast iron, showed that a rate of feed of ·047 per revolution was required to break the drill, and one of ·064 on a $\frac{5}{16}$-in. drill. A ⅜-in. drill could not be broken with a feed of ·064 in. per revolution, at 267 revolutions per minute. In one case a 1¼-in. drill working in machinery steel did not break until the feed was increased to ·1 in. per revolution. A feed on a $1\frac{9}{16}$-in. drill, also in steel, gave a chip measuring $\frac{9}{32}$ in. in thickness, at which the machine was pulled up. The drills used were ordinary commercial ones, and the Bickford Company attribute these results to the form of the arm of the machine, which is tubular, and therefore well designed to resist torsional stress.

This machine was one which was introduced last year. It is noteworthy, because cone pulleys are abandoned and a nest of gears substituted for effecting changes in speeds. One of the advantages of this design is, that such a machine can be driven electrically with a constant speed motor, which is preferred by many to the variable speed type. Another is, that when belt driven, the belt is not slowed down for heavy cutting, as is the case when cone pulleys are used. Then there is the rapidity with which changes can be effected. Sixteen spindle speeds are obtainable with the gear box, and back gears, arranged in geometrical progression from 16 to 256 revolutions per minute. These rapid changes and feeds enable the machine to turn out a large quantity of work. A sample of this is an iron plate 1 in. thick, in which 15 holes, ranging from ½ in. to 3½ in. were drilled within 27 minutes, which included changing of 15 drills, and speeds.

INSERTED VEES.

A curious recent American patent is for inserted vees in machine slides. The vees are of steel, and the idea is to delay their wear for an indefinite period. They are hardened and afterwards ground in place. The projecting vee is fitted by a tongue running longitudinally, the recessed vee fits in a recess which is very slightly beyond hemispherical in shape. The vees in American lathe beds are objectionable from the point of view of durability, hence the desirability of using insertion strips of hardened steel.

A NEW DISC GRINDER.

The disc grinders, in which emery cloth is cemented on steel discs, have come into favour very rapidly during the last three years. Several are now manufactured both in England and America. The latest design is that of Messrs. C. W. Burton, Griffiths and Co., of Ludgate Square, London, E.C., and it embodies a number of excellent practical features, making it a very high-class, fine precision machine. The two tables are carried on bars, which are adjustable vertically in guides in which they are clamped. Their mass is exactly counterbalanced by chains and weights. The guides have long bosses, which embrace a 3-in. steel shaft that passes through the base, near the front, and plumb beneath the locality where the grinding is done. The guides have a transverse movement to and fro along the shaft, fine adjustment being effected by a hand wheel and screw, a movable index and stop. The guides also swing upon the shaft, so that work can be surfaced across the wheels. The tables are each pivoted on a stout pin for vertical angles. They are locked square by a Morse taper pin. Horizonal angles are obtained by a gauge, set by a scale on the edge of the table and clamped. Tee slots are provided for holding work down.

The spindle—$1\frac{3}{4}$ in. in diameter—is hardened and ground, and runs in long bearings of gun-metal, with a self-oiling ring. The emery cloth is cemented on the large discs, which are of annealed steel 20 in. in diameter. These are attached to the smaller bosses behind them, which are shrunk and keyed on the spindle ends. The discs are retained in place, each with a collar registered into the boss, and fastened with a left-hand screw on the spindle end. The cloth is cemented on the discs in a press, which is fitted at the back of the machine, instead of using a separate press stand, thus economising space. Ample protection is afforded to the bearings against access of grit, and the details of the machine are worked out very well.

FOUNDRY MATTERS.

A new brass melting furnace has been designed by Mr. W. Mayer, of Dumbarton, and is manufactured by Messrs. Hardie and Gordon, of Dumbarton. It belongs to the air furnace class, but possesses several original features, one being the form in plan, which is tapered from front to back, with an arrangement of regulating shutters, exceptionally deep fire bars, and a deep reservoir or well for the molten metal. The firing is done from the broad end of the furnace. Air is admitted on each side of the firing door, through sliding shutters, an air portway is formed at the bottom of the fire door, and another just above the fire bars, suitably proportioned to the grate area. Through another opening below, air is admitted above the fire bars. The latter are of great depth—a foot or more—hanging right down into the ash-pit. Air in passing up through these bars mixes with the air which is drawn in above the bars, and produces thorough combustion of the gases. The bridge is high, and the roof deeply arched. The well behind the bridge receives the molten metal, where there is less heat than at the throat, and less risk of volatilization. The sight hole and the tap hole and spout are at one side, or tapping may be arranged for both sides. The furnace is built generally as in other designs with cast iron plates, brick lined, and one end is supported on rollers to permit of longitudinal expansion by heat. It is portable.

The furnace burns hard coal, and is very economical, melting 1 cwt. of brass with an average consumption of $\frac{1}{2}$ cwt. of coal. Three and a-half hundredweights is worked off in one heat, and six or more heats of that weight can be melted in a day, or twelve heats or more with lesser quantities. The average loss in melting gun-metal is 2 per cent., common brass 3 per cent., yellow brass 4 to 6 per cent. The brass is tapped into a ladle, as in the case of iron running from a cupola. Iron and other metals can be melted in small quantities in the furnace.

CRANES.

The writer's experience in the crane industry goes back to the period when the application of steam power was still a novelty, and when hand and hydraulic cranes, chiefly the former, were in service. The applications of air and electricity were not as yet entertained. There are many cranes yet in existence which date very long prior to that period. Some of these, of uncertain age, are timber framed, with stones for balance, and having barrel wheels with spider-like arms and narrow teeth, and are keyed on square shafts. Some of these are still doing occasional work. Many are of the well type—that is, in which the post of cast-iron goes down deeply into the ground, and is stepped into a casting at the bottom of a well of masonry. This type is often half a century and upwards old. Such cranes are still working within a radius of a few miles of the writer's home. The contrast between cranes of this kind and the modern types is sufficiently startling to call for some observations thereon.

A number of circumstances have combined to bring about this change. It is not only that the demand for labour-saving devices in handling material has become as great a feature in modern industry as the demand for increased production of machine tools. But for the fact that many developments have greatly favoured the growth of big and highly mobile cranes, we should not yet have seen giants capable of lifting a couple of hundred tons, of a hundred feet radius, and bridge cranes of 200 ft. span and more. As long as timber, cast-iron, hand, and steam-power were the principal elements available, growth could not be very rapid. Massive cranes were made then, but they were clumsy and slow. Not until the possibilities introduced by steel, electricity, and air were available, could cranes, powerful, light, and highly mobile be produced. The subject is too wide to be adequately treated here, but we can indicate some of the reasons why progress has been possible. In massive cranes the dead weight of the members composing the framing is very great, and when either cast, or solid-plated, it increases the dead load, and the load to be moved. The small dimensions in which wrought iron was rolled rendered heavy built-up plating very expensive. We say *was*, because wrought iron is now practically quite out of the running as far as the plated work of cranes is concerned. But the large dimensions available in steel plates have enabled the crane makers to build the biggest and strongest structures, with the minimum of dead weight. Instances which occur to the mind are the Benrath cranes at Bremerhaven, Brown hoisting machines, the Temperley transporters, the numerous coaling cranes, and the overhead travellers.

In the heavier cranes, the electric conductors have done away with much dead weight, substituting motors and controllers for boilers and engines, or for massive water cylinders and chains. The dead weight of crabs and trolleys is lessened thereby, and there is less vibration at high speeds. None but those who know the herculean, slow, and risky tasks involved in hauling and lifting loads about in shops which are inadequately supplied with power cranes can fully appreciate the value of the light air hoists now becoming common. They are so easily transported and handled, and so rapid in action, that in those shops where large quantities of comparatively light work are handled, the jib cranes and overhead travellers cannot enter into successful rivalry with them. They have but one, the electric hoist, which also is developing in the hands of a few manufacturers.

Another line of cranes which has been developed largely by the use of steel and electricity is the portal, or gantry cranes, for dock and wharf service. The old wharf cranes blocked the roadway, and when operated by water, lines of pipes liable to freeze often gave trouble The portal cranes reach clear over the road, and take current readily. Their framings are braced and light, lessening weight to be moved, and their jibs, often curved, and high up, command the work to be done more efficiently than when they are stepped into the old type of portable wharf crane. There is no branch of engineering, not even machine tool construction, which is advancing more rapidly than crane manufacture and design, and none which is of greater interest to those who know the practice of earlier years.

PAGE'S MAGAZINE

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OUR MONTHLY RÉSUMÉ.

LONDON, 20th September, 1902.

The Largest Ship Afloat.

The largest vessel ever built was launched last month from Messrs. Harland and Wolff's Shipbuilding Works, Belfast, for the White Star Line. This new vessel, which is named the *Cedric*, is 700 ft. long. Her beam is 75 ft. (7 ft. more than the *Oceanic*) and her depth is $49\frac{1}{2}$ ft. She is about 21,000 tons gross. The displacement at her load draught will be 37,870 tons. The *Cedric* has nine decks. She is built on the cellular double-bottom principle, and is divided into numerous watertight compartments, so that a maximum of security is obtained exceeding all official requirements. The *Cedric's* engines, which are of the Harland and Wolff quadruple-expansion balanced type, will drive her at her designed speed with considerably less consumption of coal than is required for a vessel of extreme speed. The *Cedric*, like the *Celtic*, will have accommodation in all for about 3,000 passengers, besides quarters for a crew of about 350. The newly-launched ship is being fitted up in fine style, and we may have more to say about her hereafter.

The Cunard Line and the Combine.

It is now reported that the arrangement by which the Cunard Line is to receive a large augmentation of the Government subsidy hitherto paid for mail carrying is practically complete, and that it is a condition that the line shall remain "all British." It is said that Mr. Pierpont Morgan was in active negotiation for the acquisition of this line, and that pourparlers to this end had been carried to a certain point, when an obstacle arose in the attitude of the chairman, Lord Inverclyde, who "put his foot down" when it appeared that the effect of the proposals would be to transfer the control of the line to America. The details of the Cunard arrangement are not known up to the time of writing. As to the lines at present controlled by the Morgan Combine, Liverpool is to be the chief centre in this country, and the British management will be localised there. Mr. Wilding, of the Leyland Line, is to be the general manager. There will be a concentration of the present separate offices and staffs, and all will be combined in the building which the late Mr. Ismay constructed in James Street for the purposes of the White Star Line.

New Battleships. Tenders are now at the Admiralty for the construction of the only battleship to be built by contract under the 1902 Naval Programme, and also for the machinery of the battleship to be built at Portsmouth Dockyard. Both vessels are of the same class as the *King Edward VII.*, now building at Devonport Dockyard; the *Commonwealth*, building at Fairfield; and the *Dominion*, building at the Vickers Company's works at Barrow-in-Furness. These vessels are 425 ft. long, 78 ft. beam, and of 43 ft. moulded depth; and with a draft of 26 ft. 9 in. they will displace 16,350 tons. The five vessels now included in this class are 1,350 tons greater than any of the ships-of-the-line in the British Navy. In speed, however, they will be behind the six vessels of the *Duncan* class now being completed, which will steam 19 knots on their full-power trials, while the new ships will make 18½ knots. The engine power is the same, 18,000 i.h.p.; but more weight is given to armour and guns in the new vessels. Their complete broadside is covered from 5 ft. below the water line to the upper deck with hardened plates, varying from 9 in. to 7 in., and right forward to the ram, where the armour is 4 in. in thickness. These ships, in addition to the usual twin pairs of 12-in. guns in barbettes, will carry four 9·2-in. guns in four smaller barbettes, as well as ten 6-in. quick-firers, fourteen 12-pounders, ten 3-pounders, and two Maxim guns, with five submerged tubes for firing torpedoes. This armament is superior to that of any ship in the Navy. The machinery will be much the same as that of the *King Edward VII.*, which has a combination of Babcock and Wilcox and cylindrical boilers. There will be four cylinders working on the triple-compound principle, the high-pressure cylinder being 38 in., the intermediate 60 in., and the two low-pressure cylinders 67 in. in diameter, with a stroke in each case of 48 in. The full power will be realised with 120 revolutions. The contract ship will have cylindrical boilers for one-fifth of the power, and Babcock and Wilcox boilers for the remainder. The Dockyard-built ship will have Niclausse boilers for four-fifths of the power, the remainder being got from cylindrical boilers worked under the Howden system. The boiler pressure in both cases will be 210 lbs. per square inch.

British Tonnage. The *Shipping Register* for July shows that there has been an unusually large production of new tonnage, and that the loss of tonnage from various causes has been remarkably slight. The result is a large addition to our merchant fleet. Of new steel steamers, no fewer than forty-nine, with a gross tonnage of 120,045 tons, were added to the *Register* during the month. With iron and small wooden vessels the total additions are seventy-nine ships of 121,896 gross tons. The removals from the *Register* comprised only eight steamers of 15,573 gross tons, twelve iron steamers of 5,701 gross tons, and wooden steamers and sailing vessels of various types, bringing the total up to sixty ships of 32,743 gross tons. These do not include vessels transferred to and from the Colonial Registry. Deducting 32,743 tons from 121,896 leaves a difference of 89,153 gross tons as the net addition to the *Register* during the month.

The "Massilia." Another new Anchor Liner has been built by Messrs. Alexander Stephen and Sons (Limited), Glasgow. This vessel, which is named the *Massilia*, is of the following dimensions:—Length, 400 ft.; breadth, 49 ft.; depth, 30 ft. 9 in. moulded; with a gross tonnage of 5,100 tons. She will be supplied with a set of triple-expansion engines, the cylinders being 26-in., 43-in., and 71-in. diameter, by 4 ft. stroke. There will be two double-ended boilers working at a pressure of 180 lbs. This latest addition to the Anchor Line fleet is intended for their Indian service, and has been built to the highest class of the British Corporation Registry. The main saloon, a very handsome apartment situated on the bridge deck, is well lighted and ventilated, and provides superior accommodation for a large number of first-class passengers. The decoration is bright and artistic, and the furniture and general appointments are very handsome. The state-rooms are aft of the main saloon, and consist of large, airy, and well-lighted two- and four-berthed rooms. From the main saloon a handsome stairway leads to the promenade deck, where a spacious music-room is provided. At the other end of the promenade deck there is a large and well-ventilated smoking-room. The vessel has been fitted with all the latest improvements for the rapid working of the large cargo which she has been designed to carry, including ten powerful steam winches. An insulated chamber for storing meat and vegetables has been provided, which will be kept constantly cool by a large refrigerating machine placed in the engine-room.

New Turbine Steamers.

The success of the two turbine passenger steamers on the Clyde is calling forth various projects for the further utilisation of this class of sea motor. One is to be employed in the cross-Channel service, between Dover and Calais. We are informed that Messrs. Denny, of Dumbarton, have received from the South Eastern and Chatham Companies an order for a turbine steamer for next season's traffic, which for speed, comfort, and convenience will revolutionise the cross-Channel passage. The Dover-Calais route will be the first sea passage upon which this new type of steamer will be employed. The length of the vessel is to be 300 ft., and she will have a beam of 40 ft., which is 5 ft. to 6ft. wider than any present cross-Channel steamer. This will give a magnificent deck space, and add to the vessel's stability at sea, prevent rolling, and reduce the inconvenience of passengers to a minimum. The ship will be provided with every up-to-date convenience for such a steamer, and will be entirely different from the present type of mail packet. The upper, or promenade deck,is to have an overhead shelter, so that in rough weather passengers can be protected without going below. This new steamer will be provided with extensive cabin accommodation. The turbine machinery occupies such a small space compared with the present heavy engines and machinery, that a vast amount of additional room will in this way be obtained for the use of passengers. As to speed, it is calculated that the cross-Channel passage will be covered by this steamer in 45 minutes at the outside, and probably, under favourable conditions, in less. The steamer will have five propellers, and be fitted with rolling chocks to add to her steadiness at sea, and her engines will be capable of producing a speed of about 25 knots an hour without vibration. At present the highest average cross-Channel steaming is 1 hour 5 minutes. Another project has reference to the building of a large and swift turbine boat for the West Highland tourist trade.

Marking Time on the Rand.

The present position in Johannesburg is one approaching stagnation, as only about one-third of the stamps are working, and there seems to be a lack of strong initiative on the part of the mining interests to terminate the present slump by a settled and combined policy with regard to the restricted supplies ,of unskilled labour and transport, which on the surface of things constitute the obstacles to renewed progress. Counsels are divided, as will be indicated by the following propositions, for dealing with the labour question, which are advocated in various quarters :—

1. The offer of larger wages to Kaffirs.
2. The importation of Indian coolie labour.
3. The introduction of Chinese.
4. Giving white unskilled labourers five shillings per day, with free food and quarters.
5. The letting of underground contracts to gangs of white men.

The first plan would undoubtedly be the most satisfactory solution if a return of the rates prevailing before the war would result in a sufficiency of labour, but it is probable that so much money had to be distributed among the natives in various ways during the war, that only exorbitant prices would bring them into Johannesburg in sufficient quantities.

The second and third propositions are strongly opposed on the grounds that large numbers of Indians or Chinese are undesirable residents in a white man's country. The experience of Natal has shown that of the coolies imported for plantation working to that country, a large proportion of them, on the termination of their indentures, elect to remain as permanent residents. The writer had the opportunity of watching an experimental application of coolie labour on the Rand in the early nineties, and the results observed were not encouraging. In Australia, again, the people have had considerable experience of Chinese immigration, and the efforts of the local Parliaments are directed towards its restriction.

Racial difficulties. The fourth suggestion is opposed by the skilled white workmen on the ground that it would tend to reduce workmen's wages all round, and there seems to be some ground for this fear. Nevertheless, at the present moment this idea is receiving the most effectual support in influential quarters. Some of the companies are building a number of rooms for the occupation of white labourers on these terms, which are at present only offered to men discharged from military service. Another difficulty in connection with this plan is the necessity for the complete separation of the white from the black labour. It will be apparent to everyone that if white men and Kaffirs were employed on the same work in mixed gangs, a fatal blow would be struck at the prestige of the white man, and results of the loss of caste upon the internal affairs of the country might easily be disastrous. It is therefore generally conceded that this separation of blacks and whites must be maintained. That is to say, that if any particular mine employs cheap white labour, say on the surface, then the whole of the surface work should be done by whites. Even with this limitation the Kaffirs will soon realise that white men are employed on the same kind of work as themselves, and this will make them less amenable to the white man's rule. This political aspect of the case seems therefore to be the most serious one.

The last proposition has much to recommend it from the mine manager's point of view, but if the contracts were let at such prices that the cost to the companies per ton milled suffered no increase, the men would probably not earn more than £4 per week, and from a miner's point of view it is certainly more pleasant to receive £5 10s. for supervising Kaffirs than £4 as the result of a week's hard personal labour.

The Outlook. In conclusion, then, it may be safely said that the tendency is distinctly towards the reduction of all salaries and wages, and that until the present conditions of stagnation and uncertainty have given place to the vigorous prosecution of some definite policy, such as is usually characteristic of the able men in whose hands lie the the future of the Rand, it is impossible to recommend any one of any calling to venture there at the present time unless his prospects are assured before leaving his home. The other difficulty referred to above, namely, in regard to transport, also affects progress considerably. Merchants cannot get more than one-third of their requirements sent forward on the railways, and batteries have to shut down owing to shortage of coal, and slimes plants stop for want of lime. We have endeavoured to give a true picture of present conditions, and its colours are not rosy; nevertheless, there is plenty of hope for the future, for the gold is still there, and there is little doubt that within twelve months and perhaps less, this district will again be the scene of activity and prosperity that it has been in the past.

Although less money may be earned per head, the amount spent in necessaries will also become gradually lessened, and that spent on whisky considerably reduced.

Occurrence of Fire Damp. Fire damp has always attracted attention in connection with coal mining, and still does; in fact, if this attention is relaxed the world is soon painfully reminded of the presence of this undesirable concomitant of coal by some direful calamity due to the effects of its sudden appearance and combustion. Some very interesting and careful experiments have been made recently, more particularly to verify points of doubt and variance existing in relation to the work of previous investigators. In some experiments samples of coal of 16-lbs. weight were pulverised by means of steel balls in a closed gas-tight cylinder, which at the start was exhausted of air and then revolved thirty-five turns a minute. After an hour the pressure of any gas in the cylinder was ascertained, the volume measured, and the composition determined. Two varieties of coal were investigated, and both yielded gas in variable quantities. Neither the chemical composition of the coal, nor its density, nor the degree of fineness of the pulverisation, seemed to bear any relation to the volume or character of the gas evolved. More gas was obtained by making two exhaustions of the cylinder each after half an hour's attrition than by a single exhaustion after one hour; this was due to some re-absorption of the gas by the coal. Coal in lumps loses its gas slowly, the combustible constituents are the first to go.

Sudden Outbursts.

This solitary fact of the occlusion of fire damp in coal having been established and scientifically demonstrated, provides, it is asserted, an explanation for all the phenomena associated with beds that are subject to sudden outbursts of gas, and also for all the conditions under which the outbursts are produced.

Precautions.

Exploratory borings should be employed, and should prove useful in indicating the probable spots where sudden outbursts of gas may be expected; but this exploratory work should not be relegated to an under-manager, neither should the position and directions of the holes be arranged by some fixed rule. The work, to have real effect, should not be left to subordinates, but should be under superior direction and should be conducted and modified so as to ascertain the peculiarities and character of each particular seam, then necessary and effective arrangements could be made to avert calamity. Such is the latest decision in this important matter. It is particularly urgent to take precautions in times when earth movements are prevalent, as the resulting disturbances are liable to set free great volumes of pent-up fire-damp.

Coal Dust Dangers.

Many and often have the dangers of coal dust impressed themselves on the public mind in a painful manner; many and often have warnings been issued about this danger, and just as often have folks neglected these warnings, and even questioned the dangerous character of dust. To such an extent has this been the case, that the Governments of our own and various other countries have held inquiries into the matter, and by searching experiment have obtained proof of the undoubtedly dangerous character of coal dust. Yet what does all this avail? One of our own Colonies furnishes a terrible example of the fact that it avails but little.

Canada's Warning.

In the Fernie mines of the Crow's Nest Pass Coal Company, we find the chief mining superintendent, in charge of a dry and dusty mine, never had the dust analysed or otherwise tested to ascertain whether it was explosive or not, neither did he have the dust removed or watered in old workings, because he considered it impracticable; and the only method of watering the dust employed anywhere in the mine under his direction was with a car and can. Moreover, the foreman and other officials of the mine were also unacquainted with the dangerous character of coal dust. Result—a violent explosion when 152 men were working in the mine. All the splendid efforts to succour and save resulted in the rescue of twenty-two men, who were already in the last throes of a death struggle with after-damp. And the jury, the Government expert, the miners' committee, and a former manager of the mine were unanimous in asserting that the explosion was caused by coal dust. Even the chief mining superintendent, already mentioned, admitted that the explosion might have resulted from his inability to remove or water the dust in the old workings. There are 50 widows and 60 families bereft by this accident. Such are the terrible lessons necessary to make some people realise that the statements and warnings of the scientific investigators are really of vital importance and worthy of serious consideration.

Government Locations.

The Canadian Government have made a move which is highly appreciated by many people throughout the Dominion, inasmuch as the Minister of the Interior has selected an extensive area in the above-mentioned coal district, which, by the way, is situate on the boundary between British Columbia and Alberta, and is said to be one of the best locations in that region. The coal of the particular neighbourhood shows on tests 74 to 79 per cent. of carbon and from 2 to 4 per cent. of ash; it is clean and firm, and yields a high-grade coke. Strangely enough, there has been such activity in the location of claims in this field, that it was only by a surveyor's error that the area now taken up by the Government was not already appropriated.

Healthy Competition.

Besides the value of the property to the Government, the acquisition has another advantage in that it introduces an element of competition which was much desired, not only to reduce prices, but to ensure more active working and a better supply. The Crow's Nest Pass Coal Company has been in operation nearly five years, and has reached an output of 2,000 tons a day; but on one outcrop seam, where work was commenced in 1898, production has not yet reached 500 tons a day.

Asbestos in Canada.

This mineral is an important factor in Canada's mining industries, and one that shows signs of agreeable vitality. In 1879, 300 tons were produced, valued at 19,500 dols.; last year the output was 38,500 tons, valued at 962,500 dols., showing an increase of 7,859 tons above the production for the year 1900. In the latter year the Province of Quebec produced 21,408 tons, thus giving employment to 1,040 workmen. The mineral is obtained by open cast workings or quarries, in which power drills and other up-to-date appliances are employed. Blondin cableways being used to take the material from the quarry to the mill.

Asbestos Enterprises.

There are in Canada twelve companies at work, with a capital of four millions, and employing 3,000 men. Bell's Asbestos Company, which is probably the best known, furnishes a good example of a successful asbestos enterprise. The capital is £700,000, of which £170,000 has been issued and paid up in full. Large profits have been earned annually from the working of the company's mines, and dividends as high as 22½ per cent. have been paid. Canada, in fact, controls the asbestos market of the world.

Canada's Nickel.

This is another valuable mineral product prevalent in the Dominion. Several of the great nickel-producing companies have already combined; nevertheless there is plenty of activity in the famous nickel region of Ontario, where there are at present extensive supplies of ore; in fact, it is so plentiful that only the richer bodies are being worked, and should these fail, the smelters could be supplied by the concentration of the poorer ores.

Process Wanted.

Many interesting and useful investigations, experiments, and trials with various processes, including, *inter alia*, magnetic separation, the ingenious Mond process, and the direct steel process, have been conducted with the nickeliferous copper ores, and have yielded valuable results. Nevertheless, heap-roasting, matte-smelting, and Bessemerising are employed wherever the ore is being treated on a large scale. Where the blast furnace is used on pulverised matte there is considerable loss in the shape of flue dust, which briquetting would only in part prevent.

China-clay in France.

Deposits of China-clay have long been known to exist in the department of the Drôme; a single deposit has been observed to extend for 1,700 ft. or more. There are four quarries quite ready for working, and there are works at Barbière, at the present time, producing 20 tons of kaolin and designed to produce from 50 to 60 tons. The operations conducted consist in washing the sand from the clay. The latter is disposed of for porcelain and pottery, the former is stored for special use.

Professor Perry on the Education of the Engineer.

At a recent meeting of the British Association, Professor John Perry, the well-known authority on engineering matters, delivered some pointed remarks concerning the training of the young engineer, and the influence of education upon our commercial supremacy. The present system of teaching mathematics and the undue importance attached to classics formed the subject of a scathing attack. "I have known the ordinary abominable system of mathematical study," he said, "to be advocated by engineers, who, because they have passed through it themselves, have really come to loathe all kinds of mathematics higher than that of the grocer and the housekeeper. They say that mathematics have trained their minds, but they do not need it in their profession. There is no profession which so much requires a man to always have the mathematical tool ready for use on all sorts of problems. The average schoolboy leaves an English school with no power to think for himself, with a hatred for books, with less than none of the knowledge which might help him to understand what he sees; and he has learnt what is called "mathematics" in such a fashion that he hates the sight of an algebraic expression all his life after." Professor Perry evidently thinks there is something radically and seriously wrong with our method of training boys for the professions generally; and that improvement lies in the direction of a system by which the pupil's reflective faculties are stimulated, and he is trained to *think* intelligently. Upon this firm and healthy basis, the Professor sees our future commercial supremacy securely established. We note with interest the robust common-sense view which Professor Perry takes of England's position as a commercial nation.

The sound judgment characterising the following extract, will, we think, be a sufficient excuse for our quoting it at length.

British Commercial Supremacy.

"No right-thinking engineer has been scared by the newspaper writers who tell us of our loss of supremacy in manufacture, but I think that every engineer sees the necessity for reform in many of our ways, and especially in this of education. People talk of the good done to our workmen's ideas by the strike of two years ago; it is to be hoped that the employers' ideas were also expanded by their having been forced to travel and to see that their shops were quite out of date. In fact we have all got to see that there is far too much unskilled labour among workmen, foremen and managers, and especially in owners. Millions of money may build up trusts, but they will be wasted if the unskilled labour of mere clerks is expected to take the place of the thoughtful skilled labour of owners and managers.

I laugh at the idea that any country has better workmen than ours, and I consider the education of our workmen to be the corner-stone of prosperity in all engineering manufacture. It is from him in countless ways that all hints leading to great inventions come. New countries like America and Germany have their chance just now; they are starting, without having to 'scrap' any old machinery or old ideas, with the latest machinery and the latest ideas. For them also the time will come when their machines will be getting out of date, and the cost of 'scrapping' will loom large in their eyes. In the meantime they have taught us lessons, and this greatest of all lessons—that unless we look ahead with much judgment, unless we take reasonable precautions, unless we pay some regard to the fact that the cleverest people in several nations are hungry for our trade and jealous of our supremacy, we may for a time lose a little of that supremacy. We have been too confident that manufactures and commerce and skill in engineering would remain with us for ever. We have had a very strong hint given us that we cannot for ever go on with absolutely no education in the scientific principles which underlie all engineering.

There is another important thing to remember. Should foreigners get the notion that we are decaying, we shall no longer have our industries kept up by an influx of clever Uitlanders, and we are much too much in the habit of forgetting what we owe to foreigners, Fleming and German, Hollander, Huguenot, and Hebrew, for the development of our natural resources. Think of how much we sometimes owe to one foreigner like the late Sir William Siemens.

In our country nearly all discoveries come from below. The leaders of science, the inventors, receive from a thousand obscure sources the germs of their great discoveries and inventions. When every unit of the population is familiar with scientific ideas our leaders will not only be more numerous, but they will be individually greater. And it is we, and not the schoolmasters, who are familiarising the people with a better knowledge of nature. When men can hardly take a step without seeing steam engines and electro-motors and telegraphs and telephones and steamships, with drainage and waterworks, with railways and electric tramways and motor cars, when every shop window is filled with the products of engineering enterprise, it is getting rather difficult for people to have any belief in evil spirits and witchcraft. All the heart-breaking preaching of enthusiasts in education would produce very little effect upon an old society like that of England if it were not for the engineer."

The Steel Amalgamation.

The rumours which have been so prevalent recently with regard to the formation of a colossal amalgamation of British steel interests have not been confirmed. The issuing of a circular, however, to the shareholders of Messrs. Dorman, Long and Co., is of interest. It announces that the directors have decided to enter into a "provisional agreement to purchase from Sir Lowthian Bell and his family 30,000 shares of £5 each, with £3 10s. paid up, being the remaining half of the ordinary shares of Bell Brothers, Ltd., thus constituting Dorman, Long and Co., Ltd., the owners of all the ordinary shares in that company, the consideration being the issue to Sir Lowthian Bell and his family of ordinary shares in Dorman, Long and Co., Ltd., of the nominal value of £225,000." This sum represents as nearly as possible the value at par of the shares in Messrs. Bell Brothers, Ltd., together with half the reserves and unassigned profits shown in the balance-sheet of the latter company. It may be remembered that Messrs. Dorman, Long, and Co., Ltd., assisted in the flotation of Sir Lowthian Bell's company in 1899, by purchasing one half of the ordinary shares. The capital of the purchasing company is also to be increased by the issuing of £250,000 in ordinary shares, which will be offered to its shareholders at par in the proportion of one-third of their present holdings, any surplus which is not thus appropriated (not exceeding 125,000 shares) being similarly allotted to Mr. Hugh Bell and Mr. A. J. Dorman. The prosperity of Messrs. Dorman, Long and Co. has fluctuated considerably during recent years, with the vagaries of varying trade; but they have always been well to the front in the contest for British supremacy in the iron and steel industry. They have neither hesitated to adopt new methods of business, nor neglected the advantages of thoroughly up-to-date equipment. At present the company's mills and furnaces are being remodelled and enlarged.

The Decrease in the American Export Trade.

The report of Mr. Bell, the British Commercial Agent in the United States, recently published by the Foreign Office, announces an enormous decrease in the American export trade, especially in iron and steel manufactures. The total value of the exports during the fiscal year, ending June 30th, shows a falling off of 104,980,945 dols. (about £25,000,000). These figures will come somewhat as a surprise to the British public, and, looked at casually, are likely to convey a false impression with regard to American prosperity. Notwithstanding this striking discrepancy between the trade of the last two years, it is a fact that the American factories and workshops of almost all industries have been working at their full pressure; but owing to the unprecedented demands for home consumption, American manufacturers have found a readier, and more profitable market for their goods at home. Especially is this true with regard to the iron and steel industry, which has been greatly stimulated by the remarkable prosperity of the railways. These have not only been purchasing rails extensively, but have been obliged to obtain much additional rolling-stock and general supplies, thus increasing the demand for a great deal of other material produced by iron and steel manufacturers. Mr. Bell states that the American furnaces have been utterly unable to meet the unparalleled demand for iron and steel for home use; and it has been found necessary to import considerable quantities of raw, semi-manufactured, and even manufactured material. At present, the boom in the home markets shows no signs of abating. It is estimated that the American railways will require at least 2,000,000 tons of steel rails alone for the ensuing year; and orders for 1,000,000 tons have already been given. We gather from Mr. Bell's report, however, that this prosperity is not likely to be protracted, for American manufacturers are already preparing for a time when it will be essential for them to take their products further afield.

"It is only too evident," says Mr. Bell, "that preparations are being made to meet this contingency. Railways are either combining or forming communities of interest with a view to carrying goods as economically as possible, especially towards the seaboard. The shipping interests have the same thing in view, so that by the time the supply greatly exceeds the demand in this country everything will be in readiness to carry the surplus to Europe and other countries more economically than has ever been done before. The large Trusts are preparing for that time. The large financial interests in New York and other centres have become so mixed up with railway, industrial, and shipping concerns that they are able to exert an enormous influence with the transportation companies in order to obtain favourable rates of transport for the Trusts' merchandise. The latest of the great combines, the Atlantic Shipping, is doubtless part of this great scheme. In the meantime, those British manufacturers who have not already done so will have an opportunity of remodelling their works, and placing them in a condition to be able to meet in a more satisfactory manner the inevitable and severe competition."

The Uniformity of Trade Catalogues.

Too much attention cannot be paid to the production of trade catalogues. It is a recognised fact that the firms which provide up-to-date and attractive descriptions of their goods are in the front rank of successful business enterprise. Much has been done in recent years to make the trade catalogue a work which will be scanned with real interest, instead of being thrown aside as a dry category of goods and their prices. In one important particular, however, there appears to be much room for improvement. Many firms, in striving after the artistic, are prone to neglect the utilitarian features of their publications, and hence we have catalogues of many varying sizes—some wider than they are high, or too high to take their place on the book-shelf where they can be conveniently referred to. There appears to be a growing understanding on the part of engineering firms that catalogues should conform as nearly as possible to the dimensions of 6 in. by 9 in. The importance of this is very apparent. In the offices of nine out of every ten engineering firms it is the custom to file all catalogues received, in order that they may be referred to at a moment's notice; and thus the catalogue of awkward shape and size is often relegated to the waste-paper basket, or stacked with other ungainly literature upon the office floor. Thus it is not readily to hand when wanted, and the consequence is that another firm, issuing a catalogue of more modest dimensions, will often secure the order. In some cases the unavoidable necessity of illustration by large diagrams will prevent an adherence to the uniform standard; but it is generally possible to issue an auxiliary volume of uniform size, and money spent in this direction will generally prove a paying investment.

NOTABLE BRITISH PAPERS OF THE MONTH.

A Monthly Review of the leading papers read before the various Engineering and Technical Institutions of Great Britain.

MEETING OF THE IRON AND STEEL INSTITUTE AT DÜSSELDORF.

THE summer meeting of the Iron and Steel Institute at Düsseldorf presented many points of interest, not the least important of which was the warm welcome extended to the members by German metallurgists and engineers, who not only did the honours of the occasion with marked spontaneity, but were ready to throw open the more important German works for the inspection of the visitors, a concession which was greatly appreciated.

The proceedings opened with a meeting of the Council at the Tonhalle on September 3rd, when the formal reception of the President, Council, and members by the representatives of the Government, civic authorities, and the Reception Committee, was followed by a selection of papers. In the afternoon an adjournment was made to the Exhibition, where, under the guidance of English-speaking experts, groups were formed for the purpose of examining the various sections of mining, metallurgy, and machinery. On the following day a somewhat similar programme, varied by social gatherings, was carried out. The Friday was devoted entirely to visiting works.

For this purpose five groups were formed, proceeding respectively to Essen (the Krupp Establishment), Dortmund (the "Union" Company, the Hoerde Works, the Hösch Steelworks), Ruhrort (the Phœnix Works, the "Rheinische Stahlwerke"), Oberhausen (the Gutehoffnungshütte), Duisburg (the Vulcan Works, the Duisburger Maschinenbau Actien-Gesellschaft, formerly Bechen and Keetman). Supplementary excursions were also arranged, and a special programme of visits and excursions was drawn up for the ladies attending the meeting.

A word should be said in praise of the detailed programme arranged by the secretary, Mr. Bennett H. Brough, including excellent plans of Düsseldorf and the Exhibition, and a map of the district, as well as much useful information on the subject of German money, cab fares, electric tramways, etc. These, with special local notes, and a section devoted to the works to be visited, formed a handy guide for the use of members.

In the following pages we reproduce a selection of the papers read at the Düsseldorf meeting, and regret that pressure upon our space prevents the inclusion of a larger number of excerpts. Besides those which are here dealt with in detail, papers were contributed by Professor H. Wedding on Iron and Steel at the Düsseldorf Exhibition ; by Messrs. E. D. Campbell and M. B. Kennedy, of the University of Michigan, on the Probable Existence of a New Carbide of Iron ; by Messrs. L. F. Gjers and J. H. Harrison, of Middlesbrough, on Results obtained in the Equalisation of the Temperature of Hot Blast ; by M. A. Harmet, of St. Etienne, on the Compression of Steel in Ingot Moulds ; and by Professor E. Heyn, of Berlin, on the Overheating of Mild Steel.

THE USE OF ELECTRICITY IN IRON AND STEEL WORKS.

AN excellent paper on the above subject, from which we take the following excerpts, was read at the Düsseldorf meeting of the Iron and Steel Institute, by Mr. F. Kylberg, of Benrath. The author describes various American appliances which have been adapted to European requirements:—

In recent years, as is generally known, the application of electricity to the driving of mechanical appliances in ironworks has grown to an unprecedented extent. This may be due primarily to the fact that the cost of generating the electric current has been reduced beyond all previous conception, and the time is even now within measurable distance when modern central power stations driven by blast-furnace gas will render the use of electric power in iron and steel works practice still more general. In fact, it appears probable that at no distant date both auxiliary steam engines and hydraulic power will be entirely superseded.

Hitherto the necessity has existed of laying down extensive steam-boiler installations, for the heating of which either coal or blast-furnace gas was required. Despite every effort to effect a reduction in the consumption of steam by the introduction of central condensing and cooling plants, as well as by increasing the efficiency of the steam engine, it was nevertheless found impossible to lower the cost of generating the power by these means till it approximated to that attainable by the use of direct-driven gas engines. The blast-furnace owner of the present day can, in fact, avail himself of a free supply of thousands of horse-power. Further developments in this direction will no doubt lead to modifications in the construction of the blast-furnace and to the perfection of it, not only as a pig-iron producer, but also as a gas producer. This, again, involves the adoption of the requisite modern gas-purifying plant, the need for which had formerly never been experienced.

The development of the blast-furnace gas engine and the electric potential possibilities thus opened up gave occasion to the metallurgical engineer to employ this energy in driving machinery of every conceivable variety. The American works in particular, which are laid out for production on a large scale, have achieved wonders in the use of electricity, although they have only recently begun to employ gas-driven engines. These American appliances have often been introduced into Europe without regard as to whether they were adapted to European conditions, with the consequent result of occasional failure. The author proposes in the following paper to describe some developments based on American experience and adapted to European requirements.

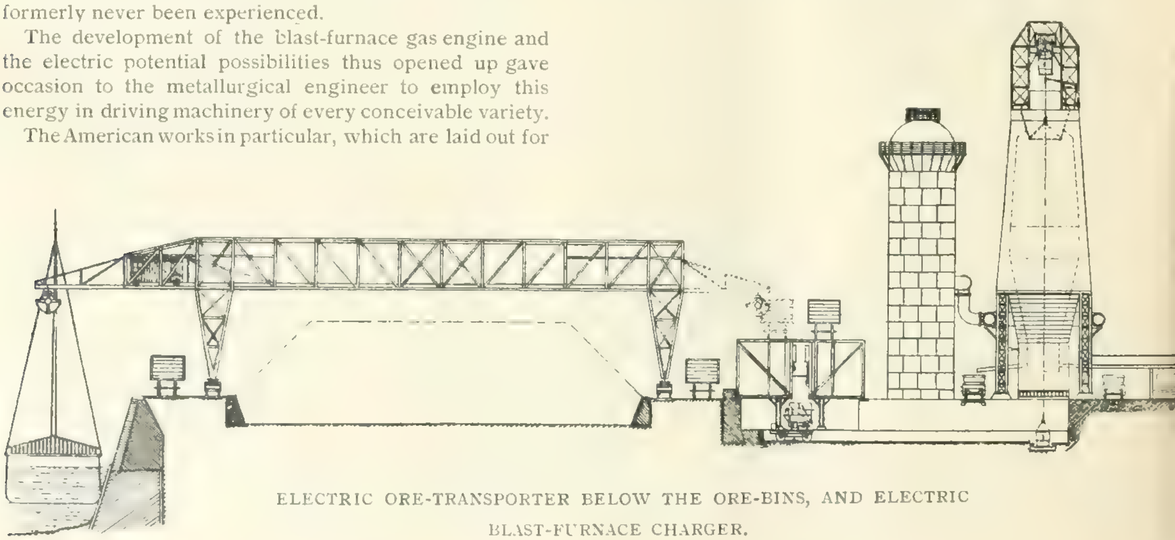
ELECTRIC SHUNTING AND MINE LOCOMOTIVES.

The great advantages of the utilisation of electric power as compared with steam are particularly noticeable in this connection, as is proved by the reduction in the cost of working and an efficiency hitherto unattainable. The following are the two types of locomotives which have proved most serviceable; first, the shunting locomotive of medium tractive power and high speed; and secondly, mine locomotives of high tractive power and low speed. Both of these types are distinguishable from one another chiefly by their general mode of construction. The following are the chief points in the construction of standard electric locomotives. Each axle is driven by a special motor, by which means great efficiency and high tractive power are assured. The motors are, moreover, arranged that any one of them can be cut out if desired, and as the result the speed of the engine can be regulated according to the load. The shocks experienced at starting and stopping are also less severe.

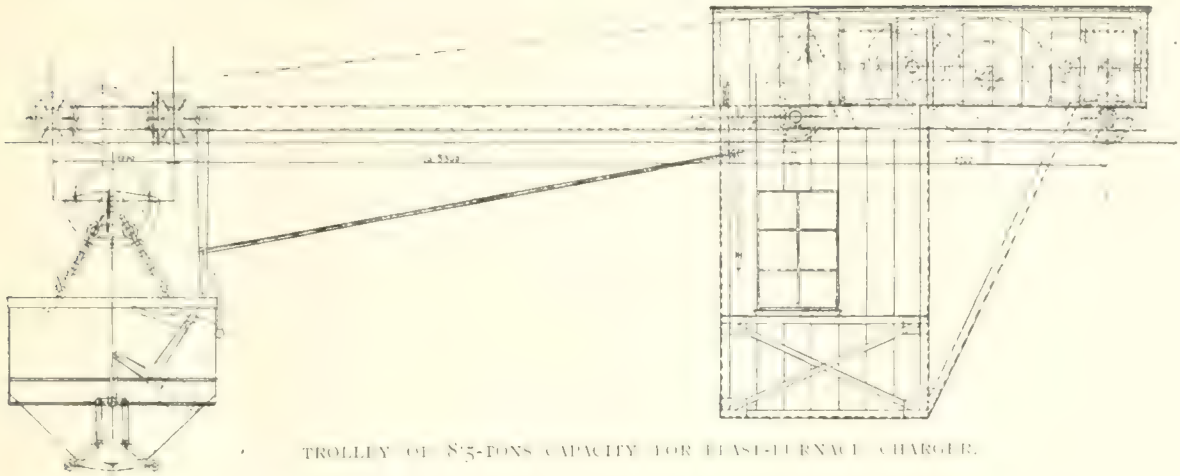
In the smaller steel works where the use of locomotives would not be profitable, electrically driven capstans can be employed to advantage. The driving mechanism of these capstans is enclosed in water-tight cast-iron casings, which are placed beneath the level of the platform so that only the round warping end of the capstan projects. These capstans are usually constructed with a tractive power of five tons.

ORE AND COAL TRANSPORTING APPLIANCES.

The construction of ore and coal unloading appliances was first developed in the United States; an arrangement



ELECTRIC ORE-TRANSPORTER BELOW THE ORE-BINS, AND ELECTRIC BLAST-FURNACE CHARGER.



TROLLEY OF 8·5-TONS CAPACITY FOR BLAST-FURNACE CHARGER.

this kind being indeed necessitated by the vast quantities of coal and ore which required transportation n the harbours or ironworks in that country. The Brown Hoisting Company was the pioneer in this respect, and has earned for itself, both in America and in Europe, a well-deserved reputation. The unloading arrangements correspond in their general features to the construction adopted by the Benrath Engineering Company, which pays special attention to the avoidance of the use of wire ropes. The transport of the materials upon the overhead track is effected by means of an electrically driven trolley, equipped with a hoisting arrangement of simple design. This trolley can be constructed with either one or two jibs, within the range of which are the ship at the one extremity and the railway track at the other. The transporting capacity of the Brown conveyers is considerable, varying between 80 and 100 tons of ore or coal per hour. It is a further advantage of this system that for the manipulation of the entire transporter only one operator is necessary. Moreover, after each lift that portion of the jib projecting over the ship is automatically drawn back, so that either the ship can be warped or the travelling bridge be moved along without the necessity of folding up any part of the bridge.

ELECTRICALLY DRIVEN ORE-TRANSPORTING ARRANGEMENTS BENEATH THE ORE BINS AND THE ELECTRIC BLAST-FURNACE CHARGER.

After the ores have been conveyed to the ore tipping ground or to the ore bins by means of the transporter previously described, it is an essential condition that the ore and coke should be transferred to the top of the blast-furnace with the least possible handling and cost of labour. For the performance of this work also electric energy is admirably adapted.

In the design of a charging apparatus described by the author, particular attention had been paid to the following points :—

(1) The whole of the mechanism was driven electrically.

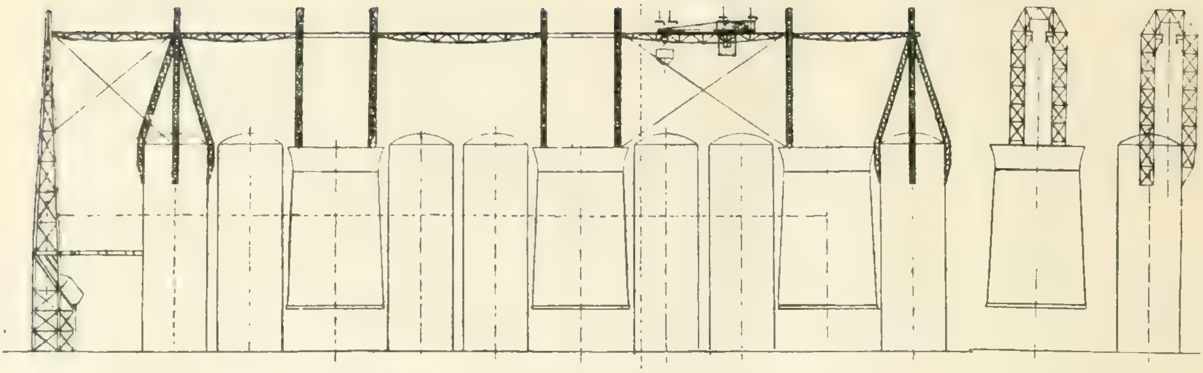
(2) Hopper-shaped trolleys were provided to run beneath the ore bins.

(3) A single hoisting arrangement served several blast-furnaces.

Parallel to the row of blast-furnaces are arranged the two ore and coal bins, which are filled direct by the ore transporter or from the railway cars on a track above them. Below these bins runs a hopper trolley, which can be filled from any one of the bins above it. A platform is built along the row of blast-furnaces, which convey the hopper to the hoist, where it is tipped into the hoisting skip. This skip is attached to a trolley, which is provided with a hoisting gear and runs on an elevated track above the blast-furnaces. The skip after hoisting is conveyed by means of this trolley to any one of the furnaces, and the contents are automatically discharged on to the bell. Assuming that a single charge which the bell is capable of supporting amounts to 10 tons, the arrangement above described can deal with a quantity amounting to 200 tons per hour.

AN ELECTRICALLY DRIVEN TILTING ARRANGEMENT FOR MIXERS, OPEN-HEARTH FURNACES, AND CONVERTERS.

For this purpose also electric power can be suitably applied. The large heavy pig-iron mixers were hitherto operated by means of one or two hydraulic cylinders, an arrangement that can now be replaced by a combination of levers, which receive their motion direct from a motor and crank. The motor is placed as far as possible from the mixer, so that in pouring in the molten metal the risk of injury by the splashing of the metal is avoided, and it is not too much exposed to the excessive heat. As regards the arrangement of motors for tilting the converter, this is in accordance with the details previously given in the case of the mixer, and the power is transmitted by means of spur-wheel and worm-gearing. The power necessary for tipping the mixer or for tilting the open-hearth furnace amounts to about 7 h.p., and the time required for the performance of the operation is not more than half a minute. For the converter, on the



BLAST-FURNACE CHARGING PLANT OF 8·5-TONS CAPACITY.

other hand, since the contents of this must also be lifted, the requisite power is about 60 h.p., and the time in this case is about one minute.

ELECTRIC ADJUSTER FOR INGOT CARS.

In most of the American open-hearth steelworks the method has now for several years been followed of pouring the metal direct into the ingot moulds when standing on small cars. By this plan the whole of the time and labour in the casting pit is saved. At the Differdingen works also this system was introduced some years ago, and is working with signal success.

The charge from the open-hearth steel furnace is tapped direct into a casting ladle, and is conveyed to a platform at one end of the casting shed. Here the steel is poured into the ingot moulds mounted on the cars, which latter are drawn forward one by one upon a track alongside of the casting platform. In order to adjust the ingot cars without moving the crane, an electric adjusting gear for pulling forward the cars is provided, and an arrangement of this description was constructed for the Differdingen works by the Benrath Engineering Company.

THE FURTHER PROCESS OF HANDLING INGOTS IN STEELWORKS BY MEANS OF (1) ELECTRICALLY DRIVEN STRIPPING CRANES, (2) COMBINED SOAKING PIT AND STRIPPING CRANES, (3) SOAKING PIT CRANES.

As a necessary adjunct to the above-mentioned method of the direct casting of ingots upon cars, the ingot stripper plays an important part. Such machines, of various design, were first constructed by the practical Americans. In the latter types, electricity as the driving medium has replaced hydraulic power. The difficulties which had to be overcome in order to adapt electricity to this purpose lay in the fact that the pressure to be exerted is very considerable in order to force out the hot ingot from the ingot mould. By the employment of screwed spindles the problem was at length solved, and there are now several such ingot strippers with screwed spindles in active operation. The ordinary electrically driven ingot stripper only draws the mould from off the ingot, and afterwards places the empty mould upon another car provided for the purpose in the neighbourhood. There is, on the other hand, an entirely new kind of construction, which is better adapted for production on a small scale. This is a combination of a stripper and soaking pit crane, by means of which it is possible first to strip off the mould and afterwards to pick up the ingots with the same tongs and convey them to the soaking pits. After reheating they are extracted and carried by the same crane to the live rollers. An electrically driven soaking pit crane with automatic gripping tongs, with the raising and lowering of the ingots effected by means of a screwed spindle, and one operator only necessary for the service of the crane and manipulation of the tongs, has been in operation for several years at the Differdingen works, and from the time that it was first put into operation has worked admirably, dealing with the entire production of ingots made at these works.

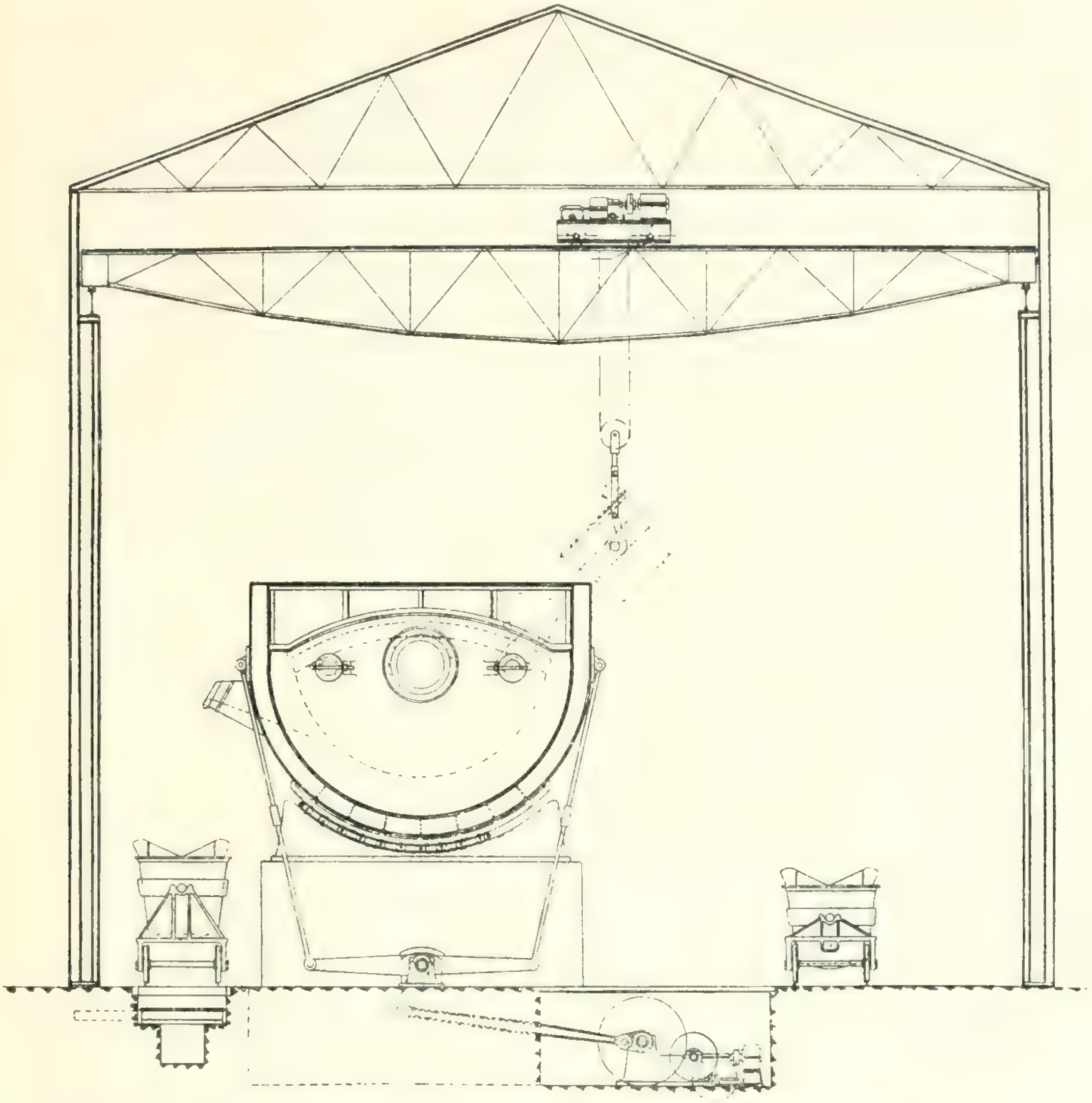
In this connection might be mentioned the well-known charging machine for open-hearth and horizontal reheating furnaces, by means of which considerable economy in power is secured, as well as in increased efficiency of the steelworks. These machines also bear further testimony to the advantage of applying electricity as a source of power in the steel-making industry.

ELECTRICAL APPLIANCE FOR LIFTING THE SOAKING PIT COVERS.

Among the more recent electrical appliances for iron and steel works may be mentioned the lever combination for raising the lids of soaking pits. By the adoption of this arrangement hydraulic cylinders, which are ordinarily used to pick up and carry away the covers of these pits, can be dispensed with. The apparatus is constructed to span one to three rows of soaking pits, and is able to serve a very large number of these.

LIVE ROLLER DRIVING GEAR.

In the general construction of electric driving gear for live rollers, as usually carried out, two motors are used for the heavier roller trains for ingots or for long transporting trains of rollers. In other cases a simple driving gear with one motor is employed for standard roller trains of lighter construction. These trains of rollers are so well known that to describe them in detail here would



HEATED PIG-IRON MIXER (WITH ELECTRIC TILTING ARRANGEMENT).

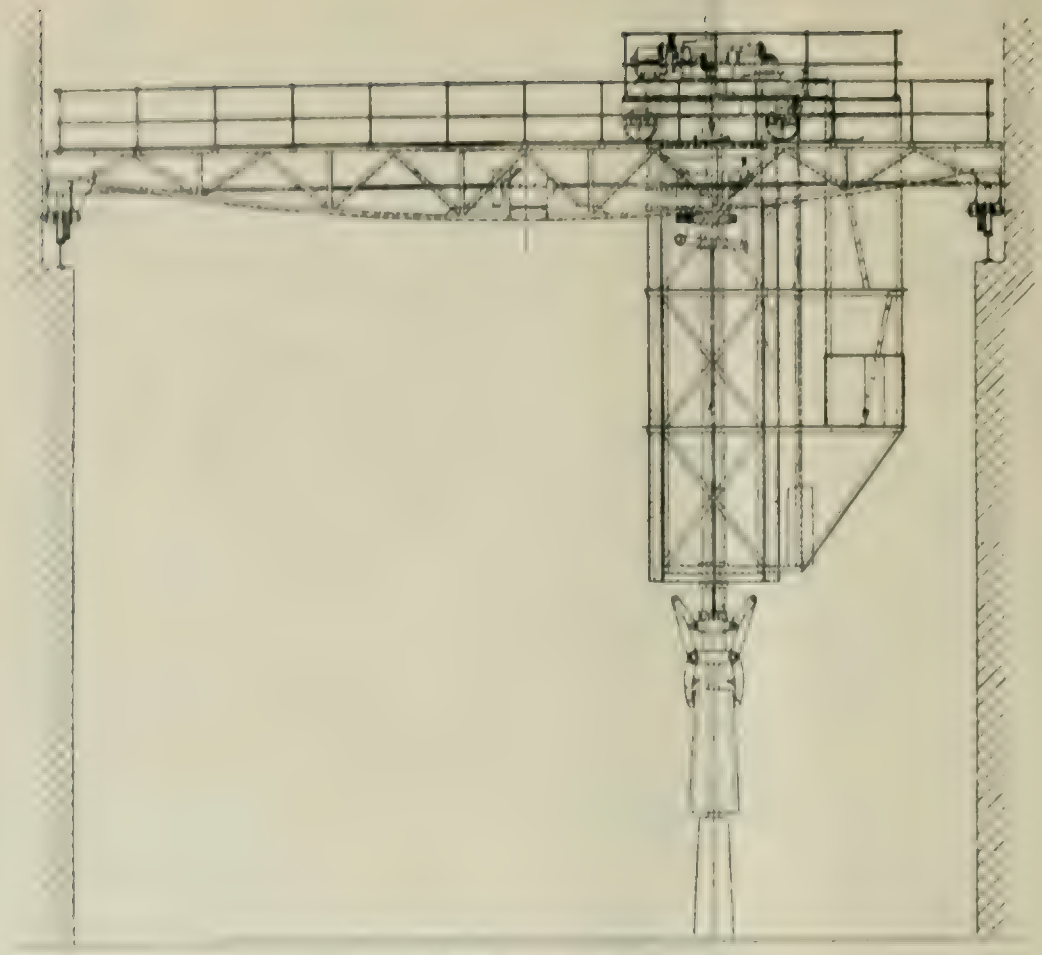
be superfluous. It is only necessary to remark that this method of driving them is greatly superior to the ordinary methods of steam driving. It has unfortunately been impossible to give diagrams and other data in connection with these electric roller driving gears on account of the shortness of time available, but the author hopes on a future occasion to be able to give fuller details.

COGGING TRAIN WITH ELECTRICALLY DRIVEN LIVE ROLLER GEAR, ROLL SCREWING GEAR, UPSETTING AND TRANSFERRING GEAR.

A cogging train with live rollers illustrated by Mr. Kylberg was designed exclusively for electric driving :—

A novel arrangement in connection with this cogging mill, which so far as the author is aware has never hitherto been put in operation in Europe, is the electric screw gear for the adjustment of the upper roll. This arrangement was first designed in [illegible] by Messrs. [illegible] Mackint[illegible] Hemphill and Co., in Pittsburg, for the various rolling mills of the Bethlehem Iron and Steel Company. At first the arrangement consisted of an electric motor, placed between the two housings, for the adjustment of the upper roll. A great difficulty was, however, experienced in keeping the motor cool, on account of the proximity to the heavy slabs and the exposure to the great heat which radiated from these.

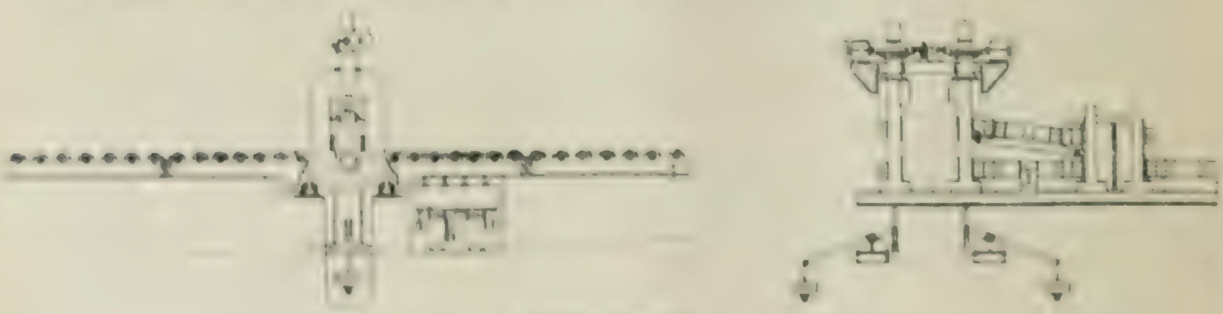
In 1889, when the Bethlehem steel works were taken over by the Carnegie interests, and were re-erected in



COMBINED PIT AND STRIPPING CRANE.

Homestead. It was soon found necessary to alter the method of driving, and the system of the motors [illegible] [illegible] the adjusting gear was placed at one side of the building, the motion being transmitted by means of links. This system was [illegible] constructed by the Wellman-Seaver Company, who [illegible] adopted an electric adjusting gear in which one motor only was employed which was fixed on the outer side of the housing.

These adjusting gears were inspected by the author on the occasion of a visit to Alabama, near Birmingham, and their working was all that could be desired. The driving was effected by means of an electric motor (fig. [illegible]);



[illegible] [illegible]

[illegible] work of adjustment.

[illegible]

ELECTRICALLY DRIVEN HOT SAW.

[illegible]

ADJUSTABLE STOP FOR REGULATING THE LENGTH OF GIRDERS CUT BY THE HOT SAW.

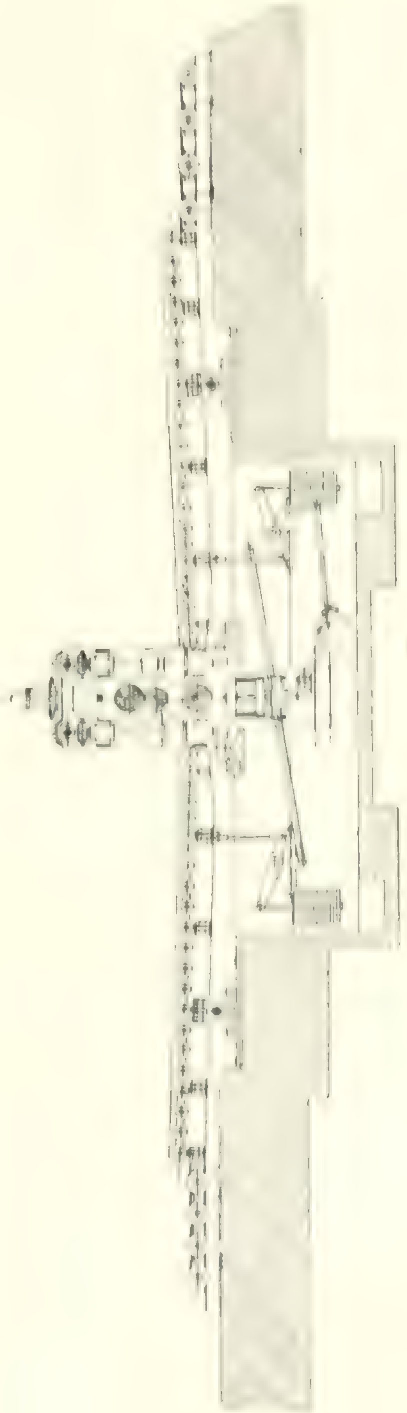
[illegible]

HOT BED WITH ELECTRIC TRANSFERRING GEAR.

[illegible]

ELECTRICALLY DRIVEN LIFTING TABLE FOR PLATE ROLLING AND WIRE ROLLING MILLS.

[illegible]



[illegible]

and a central roll adjustable by electrical means. Lifting tables of this kind have been in successful operation for several years past in America, and, in the author's opinion, the employment of such apparatus in European steel-works would be extremely advantageous. A rolling mill equipped with lifting tables of this description is at work at the Carnegie Steel Company's works in Pittsburg, and the author noted on the occasion of his visit that they were capable of being reversed twenty times per minute without overstraining the motors in any way. In general the following principle may be taken as applicable in the standard practice of electric driving in ironworks: that the motors should be of as nearly as possible the same power and type. By this means the cost of repair is lessened, and the changing of the working parts when worn out can be more easily effected.

In conclusion, the paper describes the advantages of electrically driven rolling mills and cranes:—

CANTILEVER CRANES.

In the stock-yard of a large ironworks it is also of considerable advantage to employ the system of cranes known as cantilever cranes, which traverse the whole length of the yard, and are so constructed that the projecting arms of the centre crane can just touch the outer extremities of the two outside cranes. By means of this arrangement the expensive structural ironwork for long runways can be dispensed with, and the entire yard can be served by means of this most simple arrangement. A further advantage also consists in the great economy of power in transporting comparatively light loads, since a single heavy crane need not be employed. In order to reduce as much as possible the great number of revolutions of the electric motors, a worm-gearing can be employed with advantage. These have now been brought to so great a state of perfection that an efficiency of 90 per cent. has been obtained.

THE APPLICATION OF ELECTRIC POWER IN THE IRON AND STEEL INDUSTRIES.

At the Düsseldorf meeting of the Iron and Steel Institute an instructive paper on the above subject was read by Mr. D. Selby-Bigge, of Newcastle-on-Tyne. In placing this paper before the Iron and Steel Institute, the author's one endeavour has evidently been to show what are the immense possibilities and advantages to be derived from carefully considered electric power schemes. He has succeeded in putting the subject forward plainly and in a practical light, the thirty-two pages of his valuable contribution containing data, information, and subjects for much thought and consideration.

SAVINGS EFFECTED IN WORKS.

For the Hamburg quayside cranes the total working expenses were as follows: Wages for cranesmen, coal or electric current, cleaning and oil (excluding, however, repairs) per ten hour run per crane, taking the average during the year:—

	Cost per Ten Hour Run.	
1. Brown single steam crane	10s.	
2. Steam-winch crane...	8s.	1893-94
3. Steam crane driven through pipes from steam plant...	12s.	
4 Electric crane	7s.	1898

In 1901 the working cost of 182 Brown's cranes came to 11s. 4d. per crane per ten hour run, whereas that of the electric cranes was the same as in 1898, viz., 7s.

In 1898 the steam cranes lifted 1,825,880 tons in 315,083 hours, the working costs amounting to £20,516 4s., so that the cost per hour (inclusive of repairs) amounted to $410{,}324 \div 315{,}083 = 1{\cdot}302$ shillings, or about 1s. 4d. per working hour.

The cost per ton lifted would be 0·2247 of a shilling, or nearly 2¾d.

The electric cranes lifted, from January 1st, 1898, to September 30th, 1898, 77,697 tons in 10,190 working hours, the costs being 2,664 shillings for current (2d. per K.W., hour) and 4,462 for wages, etc. Thus for one ton of goods lifted, the cost is nearly 1d.

Taking next the case of the Westinghouse Air Brake Company, Wilmerding, Penn., U.S.A., the boilers in this shop were formerly driven in groups, 30 steam engines, aggregating 1,375 h.p. being used for the purpose. The engines were supplied with steam from the central boiler plant. For this system was substituted an alternating current system, the generators supplying induction motors driven by Parsons' steam turbines; the shafting used was divided into shorter lengths, and the 30 engines were replaced by 57 motors, aggregating 1,065 h.p. In order to have an accurate comparison of the two systems, several tests were made, extending over some days, with the following results: The reduction in steam consumption was found to be 40 per cent., and the reduction in coal consumption $32\frac{1}{10}$.

Before a meeting of the Franklin Institute in 1901, Mr. Samuel Vauclain, Superintendent of the Baldwin Locomotive Works at Philadelphia, U.S.A., stated that if electric driving in their works should be abandoned, the manufactured product would cost 20 to 25 per cent. more for labour, and the floor space would have to be increased 40 per cent. to maintain the present output.

At a large colliery in South Durham the pumps were originally of the spear rod type, worked from bank, and the pumps delivered about 1,000 gallons per minute against a head of 400 feet.

Owing to the room which these pumps occupied in the shaft, and it being desired to put in another cage, which could not be done with the pumps in the shaft, the pumps were removed and in their place was substituted a horizontal compound coupled engine of 400 h.p., one 250 K.W. dynamo arranged to drive the two pumps at present installed, also an additional pump, and the coal cutting machines.

This machinery was placed at a colliery where they were able to utilise coke oven gas. The colliery being 1,000 yards from the shaft where the pumps were originally installed, the current was carried overhead by cables and down the shaft by two sets of 11 by 18 three-throw pumps, each delivering 500 gallons per minute against a head of 400 feet.

It is estimated that the saving in fuel alone is over £1,500 per annum; in addition to this the shaft can now be used for winding, and the output of the colliery very considerably increased.

In one of the collieries in Northumberland the workings were pumped by means of seven single-barrel pumps, each set delivering about 100 gallons per minute, these pumps being driven by an endless wire rope from two hauling engines, steam being supplied by locomotive boilers underground.

This plant was taken out, and in its place was substituted a horizontal engine with automatic triple expansion gear driven on to a dynamo, and the existing pumps were utilised, the pumps being driven through machine-cut worm gear by 6-h.p. motors, and in all eight sets were so arranged.

The total cost of the electric plant, exclusive of erection, was a little over £3,000, and the annual saving was from £1,500 to £1,800.

The author then proceeds to give other very interesting examples of savings effected in works, which we regret we have not space to reproduce.

COST OF PRODUCTION.

The author has frequently been asked a very obvious and reasonable question, viz., what is the cost of production should we adopt an electric plant in our works? In answer to this the author has drawn upon a number of cases of different kinds and in different parts of the country, showing the rate at which the works owner can generate his own electricity. These figures are taken from actual examples of every-day working, and are not in any way test figures taken for the purpose of this paper. Taking these figures as a basis, it is an easy matter for a works owner, once having ascertained the total horse-power which will be involved in the driving and lighting of the entire works, to see for himself at what expenditure per annum he can run his works upon the new system.

COST OF ELECTRICITY DELIVERED ON SWITCHBOARD.

Tested 13[illegible] hours, November 17th to 23rd, 1901, Britannia Works.

Mean current (amps.)	[illegible]
[illegible]	[illegible]
Mean power (watts)	433,000
[illegible]	[illegible]
Board of Trade units	60,403
Weight of steam per B.T.U.	27·52 lbs.
Weight of coal per I.H.P.	3·04 lbs.

[illegible] per B.T.U.		[illegible] per week
[illegible]	[illegible]	£47 4 0
Water 27·52 lbs. at 3½d. per 1,000 gallons	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
Wages	0·00625	[illegible]
Repairs	[illegible]	[illegible]
Superintendence	[illegible]	[illegible]
[illegible] per B.T.U.	[illegible]	[illegible]
Interest and Depreciation [illegible]		
[illegible] per [illegible]	[illegible]	

COST PER I.H.P. PER HOUR.

[illegible] per ton	[illegible]
Water [illegible] lbs. at ½d. per 1,000 gallons	[illegible]
Stores	[illegible]
Wages	[illegible]
Repairs	[illegible]
Superintendence	0·0089
	0·22423d.

Mean I.H.P. [illegible] 75 per cent. [illegible] coal per I.H.P. [illegible]

Water per I.H.P., 154 lbs.

The author is indebted to Messrs. Richardson, Westgarth and Co., Ltd., West Hartlepool, for the following information on the subject of the economy effected by the introduction of electric driving into their works. The following is a rough summary of the changes which have been effected:—

These works were formerly driven by about thirteen small and uneconomical steam-engines scattered about in different places, the maximum aggregate indicated horse-power of which would approximately be, say, 300 to 400.

Steam for these engines was furnished by a battery of twelve boilers, and the coal consumption for the driving of the works was approximately 100 tons of coal per week.

Five years ago the driving arrangement of the works was remodelled by the substitution of electric-motors for the various engines—a power-house being built in a central position, and equipped with two boilers, each 15 in. by 10 in., two dynamos, each of about 400 i.h.p., and one small machine of about 120 h.p.

The tools throughout the works are now giving an output at least of 30 per cent. in excess of what it used to be, and are burning from 50 to 60 tons of coal per week for the generating station boilers.

The above facts speak for themselves with regard to the economies which have been brought about by the introduction of electric-driving into the works.

The machinery throughout was constructed by Brown, Boveri and Co., and is of the three-phase alternating current type.

The cost of renewal and repairs over the period during which the machinery has been running (five years) has been extremely small, certainly not 1 per cent. of the value of the installation.

The managing director of a large engine-works informed the author that they are now running their works on 7½ tons of coal per day, and are employing 800 men.

Their work consists of four distinct yards, all yards are driven from one central station, and in the old method a

[illegible]

[illegible] would have to be placed in each department or else long lines of wasteful steam-pipe.

Their cost of production, including interest and depreciation on capital, is 0·46 of a penny per unit.

At a shipyard on the north-east coast, using only 112 h.p., the cost of production of electricity has been found to be only 0·6 of a penny per electrical horse-power per hour, this figure including all charges, interest, and depreciation.

At another shipyard on the north-east coast the saving effected by the substitution of electricity for steam driving shows a saving of 43½ per cent. per £ wages paid by the adoption of electric power.

The figures are as follows :—

COST OF POWER PER £ WAGES PAID.

Coal and Gas.

May 2nd, 1893, to April 24th, 1894.

Wages ...	£64,885
Cost of power	2,337

= 8·66d. per £ wages paid.

Electricity.

April 30th, 1900, to April 30th, 1901.

Wages ...	£126,7[illegible]
Cost of power	2,578

= 4·88d. per £ wages paid.

Taking the case of another shipyard which was previously driven by gas engines, the author has received the following particulars: "We have no hesitation in saying that we are getting at least 30 per cent. more power out of our machines since we adopted electric power instead of the gas engines we used before.

"As far as the cost per B.T.U. goes, we have lately had readings taken, and find that last year's works out at about 0·8 of a penny; this is taking into consideration the depreciation on our plant, interest on capital, repairs, and in fact everything which we can possibly put down against this account."

The average output would not exceed 250 to 300 horse-power.

The author is indebted to the managing director of another large shipyard in the North of England for the following statement : "Some years ago just about the time when we first introduced electrically driven machines we put in new boilers in place of the old ones, and while it must be remembered that the new boilers are more efficient than the old ones, I would say in general terms that our coal consumption has been reduced by some 40 per cent., although the amount of machines driven electrically is now greater than those which were formerly driven by steam, and consequently the reduction may be even greater than the percentage I mention above."

In a letter the author has received from Colonel R. E. Crompton, he states :—

"In our works, which are on a somewhat extended scale, the substitution of electric driving for the old shafting system has approximately halved our bill for power ; in fact, the whole of the driving of the works and tools for about 1,300 men is practically supplied by one 120 K.W. set fully loaded, and it is only when we are testing that we have to run two sets of this size, whereas by the old system we should have had to run two 200 h.p. engines continuously."

In summarising the above cases, it is obvious that the greatest economy results in the substitution of electricity for steam in those cases where the units of power, both in engines and boilers, are the most subdivided.

There are, however, enormous advantages to be derived, especially in the case of intermittently working machinery, where the load is of a very variable nature, and particularly so in all crane work, which plays such an important part in all our engineering industries.

MACHINERY TESTS.

The author then gives an entirely new and complete schedule of tests, which have been carefully and accurately obtained by members of his staff during the past few months, and he trusts that engineers and managers of works may find these figures of some practical service and guide to them in deciding upon the horse-power of motors to be adopted for the driving of various classes of machinery. The list will be found to embrace the greater part of those tools usually found in all engineering establishments.

THE DEVELOPMENT OF ELECTRIC POWER COMPANIES.

During the past two years great activity has been displayed in England in the formation of large electric companies, dealing with extensive tracts of country and covering under their parliamentary powers vast areas for the supply of electricity in bulk to tramway companies, electric light companies, works owners, and for manufacturing purposes generally.

In certain cases, and under favourable conditions, with regard to the district to be supplied, these companies may meet with success, but in many cases the author is of opinion the matter has been rushed into somewhat precipitately. Taking, for instance, a district of a fairly concentrated character, or in which a large number of small works and factories exist, absorbing each, say, 100 to 200 horse-power, it might be found that with the power company supplying them with electricity at 1d. per unit it would be more profitable and convenient to them to obtain their power from the company in preference to laying down their own plant. In cases such as this, the power companies should have a good field before them. When, however, the power company enters the field in districts where all the works are of an extensive character, and absorb 500 to 5,000 horse-power in electric current each, the case changes its aspect, and it will be found that it will be more profitable for the works owners to produce their own power.

On examining closely the cost of production of electricity by works owners in their own works, it is quite clear that with generating stations of 400 horse-power and upwards, equipped with economical and modern appliances in the shape of high-pressure boilers, mechanical stokers, triple expansion condensing engines, working with superheated steam, etc., the cost of production should not exceed ½d. per Board of Trade Unit, inclusive of interest and depreciation on the capital outlay. With blast-furnace waste gases this figure would be still less.

The author is of opinion that in the case of power stations in works dealing with 1,000 h.p. and upwards, and laid down upon the most modern lines, this cost of production can be reduced to 0·4d. per B.T.U., as shown in the case of Messrs. Dorman, Long and Co.'s works.

ADVANTAGES OF WORKS BEING DRIVEN ELECTRICALLY.

We have in Great Britain been somewhat slow in making use of all the advantages which electricity has enabled us to reap. In many parts are to be found the same old low-pressure boilers, which have done service for the past thirty years, with working pressures as low as 15 lbs. per square inch. In other works are still to be found the same old beam engines constructed in the days of Watt and Stephenson. Works are still to be found in which over 100 small high-pressure and non-condensing engines are distributed with their mileage of steam pipes throughout the works—little or no attempt having been made to improve this state of affairs. It is in cases such as these the author trusts this paper may be of service, by showing clearly and in a practical manner the actual result which would accrue from the remodelling of the driving arrangements upon the electrical method.

In no country have we finer examples before us of the achievements of electricity as a motive power than in Germany, and we must all admire the skill, ingenuity and, above all, the enterprise of our German friends in this direction.

There are many outlying advantages which would accrue, were works and industrial establishments driven electrically. There would be an enormous reduction in the smoke produced in large manufacturing centres, and a proportionate increase in a healthier state of things for the inhabitants.

In these days, when the idea of coalfields giving out is mooted, there would be a perceptible difference in the quantity of our coal consumption, which, although perhaps unpalatable to the coal-owner, would be most welcome to the manufacturer, who aims at the lowest cost of production. The application of electric power to the iron and steel, engineering, and manufacturing industries in Great Britain has certainly not developed with anything like the rapidity with which it has progressed in America and on the Continent.

THE POSITION OF THE ENGLISH WORKS MANAGER.

Generally speaking, the power and responsibility vested in the general manager of a works in England are very different to what they are in a works in America. There the position is one of much greater latitude in the scope of innovations and improvements, and of responsibility also.

The actual result, therefore, is that improvements and savings are rapidly carried out, and the board of directors look to their manager for the expected improvement and savings, owing to the manager's minute knowledge of the details of the scheme he is putting forward and his great sense of responsibility in the matter. In the author's experience in dealing with firms in England, he has most frequently been struck with the small scope of initiative action allotted to the works manager, nearly every innovation and improvement being referred to the board of directors. This in a very large degree appears to be the cause of a retarding influence on electric power progress in our country.

In brief, the scope and responsibility vested in the works manager in America is very different to that allotted to the works manager in England. The board of directors' decision is responsible for the results obtained, and the works manager carries out the wishes of the board; on the other side the works manager is directly responsible to the board for the innovations that have been carried out.

There is one point that has most forcibly struck the author in dealing with improvement schemes for works. Outside of our own country he has invariably been met with a first question, "What is the saving to be effected under the proposed scheme?" In England the first question put is, "What is the cost going to be?"

Both are naturally very important considerations, but many is the time that really great and immediate savings have been left unconsidered by that one glance at the first cost, and the documents have been pigeon-holed and shelved, only to be brought out when absolute necessity, not real enterprise, compelled them to be resorted to again.

In the many uses to which electricity has been applied as motive power, none has proved more suitable than its application to shipyards, dockyards, and other works of this description possessing a great number of scattered and intermittently working machines. Our great dockyards both at home and abroad offer a case in which enormous savings could be effected. The reduction in working costs of a number of shipyards with which the author is acquainted has varied between 30 per cent. and 60 per cent. If this same saving could be effected in similar establishments, such as our Government dockyards, the result would be highly beneficial to the country.

THE PROGRESS AND MANUFACTURE OF PIG IRON IN GERMANY SINCE 1880.

At the Dusseldorf meeting of the Iron and Steel Institute, Mr. W. Brügmann, of Dortmund, read a notable paper dealing with the unprecedented development of the German iron industry.

A comparison of the entire world's production of pig iron (18,300,000 tons) in 1880 with that given for 1901 [illegible] tons shows that in [illegible] production of pig iron has been more than doubled. Almost the whole of this increase may be apportioned between the two countries, Germany and the United States. In 1880, the United States ranked second among the iron-producing countries, with a production of 3,895,000 tons, equal to half the production of Great Britain at that time, and Germany occupied the third place, with 2,729,000 tons, or about one-third of the English output. In the year 1900 there were produced in America 14 million tons; in England 8·962 million tons; and in Germany 8·351 million tons. The production of the United States is therefore more than three and a half times, and that of Germany more than three times, greater at the present time than in 1880, while that of England shows but a moderate increase.

The author then touches briefly upon the conditions which have led to the vast increase in the manufacture of pig-iron in Germany.

Notwithstanding the unprecedented development of the German iron industry, the blast-furnace works of the country have not been able to meet the demand. In the last ten years, 1891 to 1900, the excess imports have amounted to 1·8 million tons of pig and scrap iron. It must, however, be borne in mind here that the favourable condition of the iron industry during the last few years has had much to do with this, since of that quantity more than one million tons were imported during the two years 1899 and 1900. It is probable, however, that in the succeeding years a change will occur, since in 1901 the exports exceeded the imports by 100,000 tons, and in the first half of 1902 by 330,000 tons.

Mr. Brügmann then takes *seriatim* the following seven districts, and gives numerous statistics concerning the iron smelting works there established:—

(1) Rhenish Westphalia, exclusive of the Saar district and the Siegerland; (2) The Siegerland, the Lahn district, and Hesse-Nassau; (3) Silesia and Pomerania; (4) The kingdom of Saxony; (5) Hanover and Brunswick; (6) Bavaria, Würtemberg, Thuringia; (7) The Saar region, Lorraine, and Luxemburg.

THE MECHANICAL APPLIANCES OF GERMAN BLAST-FURNACES.

The improvements in the mechanical appliances of German blast-furnaces are best judged by the fact that the workmen employed in the blast-furnace industry in 1880 numbered 22,000. At the present day some 35,000 are employed, notwithstanding the production being more than treble that of the previous period. The improvements in the appliances for transport of raw material and iron have chiefly contributed to this reduction in the proportion of manual labour.

Extensive shunting stations with central signal-boxes, and weigh-bridges with hydraulic or electric counter-balancing arrangements, have been laid out. By means of these the long trains of ore waggons can be conveyed in a minimum of time to the raised tracks laid over the ore tipping ground. It is particularly essential that those works situated in the coal district, which obtain their ore from abroad, should possess facilities for stocking several cargoes within a few days. The necessary space for stocking large quantities in ore-bins is generally provided beneath the tracks on to which the ore waggons are run. The waggons themselves for transporting the ore are self-discharging, being fitted with flap side-doors The Talbot waggon is arranged to discharge its load on either side of the track.

Unloading appliances of American type (Hunt and Brown) are employed to convey the ore from the holds of vessels to the furnace-yard. The Krafftwerk at Kratzwieck, near Stettin, the Vulcan at Duisburg, the Krupp works at Rheinhausen, the Union Company at Dortmund, all have installations of this kind.

Aerial wire ropeways exist in almost every ironworks. The firm of Pohlig and that of Bleichert have constructed a number of remarkable systems of ropeways. These are often employed to convey the ore or coke direct to the top of the furnaces, or for the removal of the crushed slag. At the Henrichshütte at Hattingen the whole of the raw material is carried to the blast-furnace by means of these suspended tracks.

Where it is not the practice to grind the slag, it is got rid of by pouring it into tubs on tipping waggons of about ten tons capacity; or it may be removed in ladle waggons similar to those for liquid metal. The waggons are very often of standard wheel gauge. A number of these have been built by the Junkerather Company.

Owing to the certainty with which the phosphorus, the heat-agent in the basic process, can be introduced into the pig iron, the practice of conveying the iron in the liquid state from the blast-furnace to the steelworks has been everywhere adopted where the local conditions were favourable. Mixers with tilting arrangements, which contain up to 250 tons of metal, are also installed at almost all these works. Among many other advantages attending the transport of liquid metal, not the least is the great economy in labour gained thereby. Under these altered conditions the term "pig iron," familiar also among German iron-workers, certainly appears to lose its significance. Casting-machines have not been adopted in Germany, for the reason that almost all the iron is sold according to analysis, or is at least carefully sorted.

In recent years the exterior of the blast-furnace has undergone considerable modification. The heavy cast-iron columns supporting the cast-iron bearer plate are now seldom used, nor is the framework, consisting mainly of four corner columns carrying the top charging platform. In the newer installations eight columns are arranged round the furnace-body, standing upon the foundation below the free-standing hearth. These are carried up to the charging platform, and the wrought-iron bearer plate is supported on brackets projecting from them, also the platform giving access to the tap-hole and the tuyeres. The casing of the hearth and boshes is constructed of strong rivetted plates, though it often occurs that the boshes are constructed with cooling rings and wrought-iron hoops. The furnace-body is held together by strong hoops. The expansion of the furnace-body is provided for by means of stuffing boxes beneath the charging platform. At some works the furnaces are built of bricks of small dimensions, laid with cement. Carbon bricks are also much used. Mr. Burgers, of Schalke, has constructed a furnace at the Vulcan Works, the body and bosh of which consist of cast iron, lined with fire-brick. This furnace has been nearly three years in operation, and the working has been perfect, even though he has blown hot-working iron alloys, such as ferro-silicon. A model of this furnace is shown in the Exhibition. At the Hoerde Works, Mr. Von Vloten has placed at the tuyere level a ring formed of water-cooled bronze wind boxes, which rests on a heavy ring-casting.

The dimensions of the newer blast-furnaces in the coal district and the minette region vary in the following degree :—

	Metres.
Height - -	22 to 25 (72 to 82 feet).
Diameter of throat -	4 to 5 (13 to 16½ feet).
Diameter at the bosh -	6 to 7 (19½ to 23 feet).
Diameter of the hearth	3·5 to 4·5 (11½ to 15 feet).

DAILY OUTPUT OF THE GERMAN BLAST-FURNACES.

As regards the daily output of the German blast-furnaces, this amounts to about 200 tons per furnace per day. In the minette district it averages somewhat less and in the coal district a little more. Much higher productions are achieved in individual cases. An inquiry addressed to the Deutscher Kaiser Company elicited the reply that in 1902 the daily output of one furnace had been 518 tons, while the combined output of four other furnaces was 1,661 tons, or 415 tons per furnace. The extraction from the ore mixed with flax charged was 42 per cent.

The employment of labour at the blast-furnaces varies exceedingly, so that comparative data are scarcely obtainable. To add to the difficulty, the particulars submitted by the works frequently include the industries connected with iron-making, such as coke-making, brick factories, etc. Again, those works which manufacture every kind of iron naturally have to stock ores of all kinds on a large scale, which increases the cost of transport of raw material. Finally, those blast-works which treat the pig iron in the liquid state can economise considerably in labour.

Still, the figures for some of the works may be of interest :—

Jan. 1 to June 30, 1902.	Production.	Number of Workmen.	Output per man per year.
	Tons.		Tons.
Deutscher Kaiser Co....	[illegible]	[illegible]	[illegible]
Hoerde Verein ..	[illegible]	[illegible]	[illegible]

The following data were also given by the kindness of the Hoerde Verein :—

BLAST FURNACE WORKS AT HOERDE.

Year.	Production of Iron.	No. of Workmen Employed at the Blast Furnaces.
	Tons.	
1880-81 ..	77,276	602
1881-82	82,204	575
1882-83	90,048	583
1883-84	94,078	650
1884-85	99,442	558
1885-86	106,468	540
1886-87 .	91,256	574
1887-88	131,633	513
1888-89 ..	121,868	470
1889-90	134,785	478
1890-91	122,618	478
1891-92	147,500	497
1892-93	146,570	491
1893-94	178,702	517
1894-95 .	181,241	565
1895-96	215,835	583
1896-97 ..	218,640	581
1897-98	230,000	604
1898-99	250,956	645
1899-1900 .	274,099	772
1900-01	270,444	800
1901-02	255,720	685

The maximum output at any one furnace at Hoerde was 238 tons.

PROGRESS IN STEELWORKS PRACTICE IN GERMANY SINCE 1880.

Mr. R. M. Daelen, of Düsseldorf, read a valuable paper on the progress of the steel industry in Germany, before the Iron and Steel Institute, giving in as brief a space as possible, an account of the recent progress and more important improvements which have been effected in the production of steel on a large scale.

Since the last occasion on which the Iron and Steel Institute visited Germany in the year 1880, a notable development has taken place in the production of steel in this country, and to-day again, as formerly, the Industrial Exhibition of the Rhine Provinces and Westphalia affords a fitting opportunity for taking note of the progress which has been achieved in recent years.

METHODS IN USE FOR THE TREATMENT OF STEEL.

After a brief review of the general situation in the German iron industry the author says :—

Returning now to the methods in use for the further treatment of steel, it will be found that the older-established works have for the most part retained the well-known system of casting ingots, consisting of a hot-metal ladle carried either on a slewing or travelling crane, and successively placed above the stationary ingot-moulds. On the other hand, only a few of the more modern works have adopted the reverse method of drawing the ingot- [illegible] be combined with [illegible] the ingots from their moulds by mechanical means.

The latter method does not permit of filling several moulds at once by bottom pouring, and its adoption has extended according to the ability to roll rough ingots at one heat into finished products such as wire, rods, small sections and plates, which formerly had to be reheated after one rolling. By this means in many works the blooming rolls are dispensed with, an arrangement, however, which is only profitable where the daily production is a perfectly regular one, such as is usual in the very large basic Bessemer steel-works.

It is the special aim in these works to roll down the ingot at the original heat, that is, by the use of the Gjers non-fired soaking-pits. The Gutehoffnungshütte first developed this system, and at these works the ingots after passing through the blooming-mill, are rolled without any reheating into sections, rails, and sleepers in a three-high mill. The results were so successful that other works have now followed the same plan. The steel manufactured by the basic process can be removed from the moulds, and plunged in the plain soaking-pits sooner than that blown in acid-lined converters, a fact which tells in favour of the system. It is also necessary to provide a means of transferring the ingot from the blooming rolls to the finishing rolls as rapidly as possible. When this cannot be done, as in the case of such works which have no blooming-mill, soaking-pits, fired on the Siemens regenerative principle, are employed, though the disadvantage then arises that the entire charge is heated at one time, and that the subsequent introduction of cold ingots has the undesirable effect of cooling those still remaining in the pits. To obviate this difficulty many works employ in connection with the soaking-pits the [illegible] furnaces of Helmholtz, or [illegible], with a very long hearth and fired at one end, in which the ingots are carried forward to meet the flames. But this apparatus necessitates too much hand labour, besides being productive of considerable waste of metal, and on this account, since the prevailing requirement is a uniform method which ensures the heating of cold ingots and the preservation of heat in the hot ingots, the American continuous reheating furnace with pushing gear has latterly been introduced in several places, the results of which are more satisfactory.

The use of electric motors for driving rolling-mills is at present very limited, and will probably only be adopted in cases where the electricity is generated more cheaply than is possible by steam power. It is, however, now very largely used for driving the auxiliary machinery about the mills, and it is generally regarded as certain that in modern works it will entirely supersede the low-pressure hydraulic machinery which formerly was in common use. Still, it must be admitted that the same precision of movement in cranes and hoisting gear is certainly not attainable by electric means, and for this reason many practical engineers of iron works still have a preference for low-pressure hydraulic power, especially as the machinery which gives it effect is constantly being improved.

In general, it may be observed that the German steel-works and rolling-mills are compelled to bestow strict attention on their plant and their practice in order to meet the requirements of their market—these are of a diverse nature, and orders for one quality or form of product are by no means of the same magnitude here as is often the case in the same industry in other countries. In arranging the buildings and machinery, the chief aim to keep in view is accordingly not only a large daily output and the saving of labour, but it consists rather in devising how to do work at remunerative rates even with apparatus and machines of medium productive capacity, and with frequent changes in the kind of material supplied. If on this account the German works are less imposing as compared with modern installations abroad, we can console ourselves with the reflection that circumstances must be adapted to meet conditions, and that limits can be set to all competition, however much this may be feared.

THE POSSIBILITIES OF "WIRELESS" TELEGRAPHY.

IN the *Monthly Review* for September Mr. Charles Bright, C.E., F.R.S.E., deals with the above subject. His article, he says, has a double object: First, to show that "wireless" telegraphy cannot at present be regarded as a serious competitor with cable telegraphy on a commercial basis; and, secondly, to point to the varied possibilities of ætheric, or so-called "wireless" telegraphy, even in the form we now know it:—

The somewhat dramatic policy pursued by Mr. Marconi has one advantage, if no other. It arouses attention to scientific possibilities—even if of the future—in a direction that the ordinary dividend-seeker of this country has not, as a rule, shown himself capable of appreciating or of interesting himself in. On the other hand, there is a certain irony attached to Mr. Marconi's selection of the three dots representing the letter S for his Atlantic experiments; for, apart from simplicity, it is just three such S's that spell sureness, speed, and secrecy—the three factors, which, at present, prevent ætheric telegraphy seriously jeopardising submarine cable enterprise. By way of substantiating the latter statement, we must turn from the pre-arranged Atlantic S signals (not messages), about which we have no details, to Mr. Marconi's best attainments in actual and accurate messages between ships and between ship and shore, at a maximum distance of about 250 miles, under more or less favourable conditions. This, be it noted, is a very different sort of thing to surmounting the earth's curvature across the Atlantic, corresponding to a mountain over 100 miles high. The difference should, moreover, be realised between catching a few more or less pre-arranged signals across the Atlantic, and that of an Atlantic cable system working continuously at a duplex, automatic speed of nearly 100 words a minute, 90 per cent. of which are cipher and code messages.

The Marconi system, which has, so far, done most of the practical work in wireless telegraphy, is fundamentally based on the coherer receiving relay, which is an excessively sensitive and delicate instrument. Whilst having obvious advantages, an apparatus of this character is, of necessity, extremely liable to get out of adjustment. For this reason it is somewhat unreliable and apt to give confused and false signals. The Marconi coherer of 1896 is, moreover, more or less readily affected by its surroundings and general conditions, including atmospheric and other natural and electric disturbances. Thus, Mr. Marconi's Atlantic experiences have been sometimes attributed to this cause alone—atmospheric "strays," and the question has naturally been raised as to how the apparatus would behave in the presence of a lightning storm. To these objections no very satisfactory answer is forthcoming at present; and until further particulars—indeed, proofs—are available, it is not unnatural that impartial authorities should question the likelihood of Marconi's system becoming a practical commercial telegraph for bridging long distances.

Mr. Bright then proceeds to deal with the important consideration of the secrecy of "wireless" messages :—

Perhaps the most important question in connection with the practical advancement of wireless telegraphy just now is to what extent syntòny can be usefully applied for guarding against foreign influences in the form of interruptions, "eavesdropping," and errors due to natural causes or otherwise. The mutilation of messages by an intervening party was forcibly illustrated during the famous *Shamrock II.* and *Columbia* yacht race of last year, as well as on other occasions; but it is believed that Mr. Marconi has effected considerable improvements in tuning the period of oscillation in his recent receiver, and his Lizard Station is said now to be more or less unaffected by the large electric power-house seven miles off. It would appear, however, that, without a monopoly of the atmosphere or an absolutely perfect screening no "wireless" apparatus could be really free from surrounding conditions and the effect of other instruments to which no limit can be placed. For this reason it has been doubted (1) whether there is any money in the invention as a system of commercial telegraphy; and (2) whether it is likely to prove useful on a large scale for strategic purposes. There seems to be no question about the possibility of "tapping" a message at will—at any rate, with an untuned receiver. On the other hand, there appears to be no absolutely sure means as yet of preventing a third party (or climatic conditions) effecting such interruption. Whilst it is perfectly true that by the use of a code the secrecy of messages is to a great extent assured, it may reasonably be doubted whether ætheric telegraphy—as yet, at any rate—is sufficiently reliable and accurate for code or cipher work. To render wireless telegraphy a really practical business and an efficient means of "All-British" communication in times of war as in peace, the following conditions will require to be attained: (1) The apparatus must be capable of being "tuned" to a certain pitch—*i.e.*, a certain number of vibrations in a given time—in such a way that the message is strictly confined to that particular receiver; (2) On the other hand, to meet naval requirements, the apparatus on board a warship should be capable of picking up the tune of any of the enemy's ships; (3) Yet again, means will have to be found for overcoming the possibility of a message being rendered a mere jumble by the intervention of a third party, or of the elements.

Discussing the practical uses to which "wireless" telegraphy may be put to in the future, he remarks :—

From a strategic point of view, as well as from a general maritime and life-saving standpoint, Great Britain and Ireland should be provided with a complete system of telegraphic communication round the entire coast, putting every coast station into connection with various inland centres and military stations. It is a piece of work which would be most effectively accomplished by wireless methods in preference to overhead lines, assuming for the moment that the strategic requirements set forth in this article could be met. For maintenance reasons, too, cables are inefficient here, owing to abrasion against rocks, strong tides, kinks, etc. Wireless telegraphy is admirably suited for lightship and lighthouse communication with the shore, to assist navigation in avoiding collisions due to darkness and fog, and also for the mercantile marine service, for vessels in distress, etc.; indeed, in any case where cables cannot be usefully turned to account, or where mere signalling, rather than high speed commercial messages, is the order of the day. May it not be asked—in the public interest, as well as in the cause of science—who is to blame for the fact that so little really useful and practical work of this description has been accomplished? Surely it cannot be the Government telegraph monopoly that blocks progress? The latter cannot, at any rate, stand in the way of wireless communications on the high seas; and with so persevering a worker as Mr. Marconi we may, indeed, look forward to the days when the fact of setting forth on a voyage need not necessarily imply being cut off from communication with the rest of the world: thus those who aspire to having news continually served up to them, even when at sea, may yet live to see their ambitions realised in a really practical way.

In conclusion, the writer points out that the imperfections of the system are likely to prevent it from becoming a serious rival to the cable companies :—

That the wireless system has come to stay is fairly obvious; but what its possibilities may reach we cannot at present foretell. Its inferiority, however, to telegraphy by cables is, at present, as marked as would be the delivery of our letters on the pavement—to be picked up by anyone—instead of in the letter-box. Cable shareholders may, therefore, take comfort in feeling that the day has not yet come—neither can we as yet foresee that it will come—when copper wires, gutta-percha coverings, and iron sheathings will be relegated to the museum of antiquities. On the other hand, it seems clear that wireless telegraphy will have an awakening effect as to our telegraphic needs, just as the electric light, by raising the standard of light required by the public, has enabled us to rejoice in the incandescent gas mantle in cases where the still better illumination obtained from electricity is conspicuous by its absence.

REVIEW OF LEADING CONTINENTAL PAPERS.

A Monthly Review of the leading papers read before the various Engineering and Technical Institutions of the Continent.

WINDING FROM GREAT DEPTHS.

ENGINES for winding from great depths are naturally very powerful, their cylinders being always near upon 1 metre (3 ft. 3⅜ in.) in diameter, with a stroke of double that figure; but compound engines are still the exception. The steam distribution is generally effected by lifting valves, with expansion variable by the governor, but with possibility of the engineman suppressing the expansion, while there are often two brake pulleys. Rescue or emergency engines are the rule both in Belgium and Germany. Sometimes, as in Belgium, they are constituted by a simple capstan; but in others, as in Westphalia, where the output is enormous, they become veritable winding engines, generally less powerful, but sometimes, again, exactly like the main engines. Appliances for the prevention of overwinding, almost unknown in Belgium, are common in Germany. Sometimes the Haniel and Lueg disengaging hook, resembling the English hook invented by Stephen Humble, is completed by a brake that comes into action if the cage should be drawn up to the pulleys; and in other cases the appliances shut off steam and put on a brake when the cage rises above the pit bank, after the manner of the Reumaux safety apparatus.

WINDING DRUMS.

Although the difficulties connected with great depth of working are, as yet, scarcely felt in Westphalia, at some mines where little over 500 metres (273 fathoms) is reached, the surface works have been laid out for winding from double that depth, in which case the engines are very large and complicated. Thanks to the lightness of the Koepe arrangement, that system is relied upon for winding from depths such as 1,200 metres (656 fathoms) and upwards; but for those at present attained cylindrical drums with balance ropes, moving freely in the shaft, or spiraloid compensating drums, are used, while timber guides for the shafts are retained in Germany, though steel rail guides are common in Belgium.

SPEEDS OF WINDING.

For winding coal the speed rarely exceeds 20 metres (65½ ft.) per second, while the mean is 13 metres (42½ ft.); and for winding men the speed varies from 4 metres (14 ft.) to 6 metres (19½ ft.) per second. Speed indicators, and, indeed, speed recorders, are fitted to the winding engines of nearly all the shafts in Germany visited by M. Deverne, chief engineer of the Douchy Colliery, in the North of France, who recorded his observations for the benefit of the *Société de l'Industrie Minérale*, arriving at the following conclusions: Cases of winding from a great depth occur nearly everywhere with the various means available on the spot; but it is evident that, as the depth increases, if a large output is to be maintained, steel wire must supersede Manila fibre for the ropes, while in many cases a limit will be imposed rather by the deposit itself and the difficulties of working it than by the winding gear proper.

RECENT PROGRESS IN GOLD METALLURGY.

FEW scientific discoveries have had such great influence on the mining industry as that exerted on gold mining by the cyanide process, which has permitted of turning to account a great many deposits that were previously regarded as refractory because they resisted amalgamation. On cyanisation being applied to the residues of amalgamation, however, it was soon seen that, if the sandy portion of these residues was easily treated owing to permeability of the sand, the slimes offered resistance to penetration by the cyanide solutions, as also to air circulation, without which these solutions cannot dissolve gold ; and this led to the residues being classed as tailings proper and as slimes. Moreover, the nature of the residues becomes modified as the mines are worked deeper, passing from the oxidised zone of the outcrops to the pyritous region underground ; and it was on this account that the pyritous concentrates, of far greater richness than the tailings which yield them, were separated by various concentration appliances.

The conditions and present practice in the Transvaal and in Western Australia, with particulars as to yield and cost of extraction, were detailed to the *Société de l'Industrie Minérale* by M. H. Kuss, Ingénieur-en-chef des Mines, who passed in review successively the treatment of slimes by filter-presses, the treatment of sulpho-telluric ores, the direct treatment of raw ore by the Diehl process, and also by simple cyanisation, as well as by roasting and porphyrisation, arriving at the following conclusions :—

TREATMENT OF SULPHO-TELLURIC AURIFEROUS ORES.

The problem of treating Kalgoorlie sulpho-telluric auriferous ores has been solved quite satisfactorily ; and a choice of three methods is now afforded, as under.

1. The amalgamation, porphyrisation and cyanisation of the raw ore, yielding about 85 or 86 per cent. for an expense of 15s. per ton.

2. Porphyrisation with bromo-cyanisation, by the Diehl process, yielding 90 per cent. for a cost of 25s. per ton.

3. Roasting, followed by porphyrisation, amalgamation, and cyanisation, also yielding 90 per cent. for a cost varying from 23s. to 27s.

Taking into account preparatory works, the ore costs on an average 20s. per ton, while general expenses vary from 3s. to 5s. Works for treating 80,000 tons per annum cost about £160,000, so that their liquidation in four years, which is reasonable, gives 10s. per ton per annum, bringing up the total expense to within £3 per ton.

The cost of extracting and treating a ton may come down to £2 10s., if roasting and the increased yield it affords be dispensed with, and even with roasting if liquidation be not taken into account ; or to £2 for works treating the raw ore by simple cyanisation. If a yield of 90 per cent. in the former and 85 per cent. in the latter case be admitted, it is easy to see that the corresponding limit contents of the ore to be treated without loss will be 14 and 12 dwts. respectively per ton. Cyanisation of the raw ore would appear advantageous for ores containing from 12 to 25, or even 30 dwts. per ton ; but for those of a higher content roasting would have the advantage.

PURIFICATION AND UTILISATION OF BLAST-FURNACE GAS.

NOW that the use of blast-furnace gas for motive power forms the subject of so many fresh investigations, it must not be forgotten that the practical utilisation of this gas is due in a great measure to Frenchmen. So early as 1814, Aubertot, an ironmaster at Vierzon, employed the gas of his blast-furnaces for heating purposes. Between 1835 and 1845 this gas was used for raising steam ; but the boilers were at the level of the furnace mouth, which was left open, the gas being drawn under the grate by the chimney draught. About 1840, and until 1855, from 25 to 40 stoves thus fired were used in the Ardennes for torrefying green wood to serve as fuel. About the same time Ebelmen studied the utilisation of gas from blast-furnaces, coke-ovens, cupolas, etc., and also, in collaboration with Sire, made experiments in puddling with the gas of charcoal-fired furnaces. A little later M. Laurens, M. Thomas and M. Robin designed gas-burners for firing boilers, hot-air stoves and arrangements for closing blast-furnaces ; and in 1857 an Ardennes ironmaster interposed a fan between the furnace mouth on the one hand and the boilers and stoves on the other, which permitted him to work with the furnace mouth open. In 1869 M. de Langlade employed at five or six ironworks a scrubber, invented by the Swedish engineer Lundin, for purifying the blast-furnace gas with which iron was puddled and the puddle-bars reheated. In 1888 M. Lespinats put up at the Neuves-Maisons blast-furnaces, gas-purifiers, resembling greatly those of Bethlehem, U.S., and which have given good results. Finally, in 1893, M. C. Cavallier, general manager of the Pont-à-Mousson ironworks, put up a dry purifier, made of large rectangular cases, filled with iron "straw," on which the greater part of the dust was deposited, this being the best arrangement when the dry method is employed.

M. LENCAUCHEZ'S PAPER.

It is with these considerations that M. Alexandre Lencauchez opened a paper on this subject of the day to the *Société de l'Industrie Minérale*, afterwards proceeding to trace successive improvements in France and other countries, dealing with fans, scrubbers and purifiers, the employment of blast-furnace gas and gas engines, while summing up with (in substance) the following observations: It may be said that the purification of blast-furnace gas is now possible, and that the use of this gas for firing boilers, hot-air stoves, refinery and heating furnaces, etc., has become thoroughly practical, because purification permits the use of regulators which maintain the combustion under constant draught and pressure, so that the useful effect can be tripled.

The author also expresses his great satisfaction at having, towards the close of his career, found a practical solution of this interesting problem, having on November 12th, 1900, written to the manager of the Micheville Steelworks that a considerable injection of water under pressure at both inlets of one of the two fans used there would probably afford excellent means of purification, and having on January 10th, 1901, patented an arrangement of multiple fan combined with water injection.

BLAST-FURNACE GAS FOR MOTORS.

As regards the motors utilising blast-furnace and other gases, he considers that there still remains much to be done, chiefly for those of 500 to 2,000 h.p. and upwards, for instance, making them work with boiling water for the sake of economy, while there would also be an advantage in substituting 2-period for 4-period motors as regards utilisation of the cylinders. Two-period engines also have the great advantage of suppressing the exhaust valve; and they permit of arranging the gas and secondary air valves in chests not exposed to the action of the flames, thus avoiding deformation of the parts. They are probably the precursors of combustion motors which, by suppressing the disadvantages of explosion, will give gas engines all the suppleness and elasticity of the best steam engines, capable of working at higher temperatures, and consequently losing far less power through the cooling currents of the jackets. In conclusion, for a plant utilising blast-furnace gas to afford absolute industrial security, the gas must be taken off at a pressure slightly below that of the atmosphere; and such pressure must be ensured automatically, because otherwise there will be the danger of violent explosions.

ELECTROMETERS—THE SCHATTNER METER.

MOST electrometers—or those, at any rate, that have come into practical use—may be classed as (1) motor meters, (2) clock meters, or (3) electrolysis meters, which were described in the following terms by Messieurs Georges and Paul Deschamps for the *Hainaut Engineers' Society*:—

MOTOR METERS,

of whatever type they be, must satisfy certain conditions. The motor must work with very slight fall of potential, and absorb but little power. Strong and compact, it must run at a speed always proportionate to the current. Friction must be either insignificant or perfectly balanced. An arrangement is generally adopted in which a certain amount of current constantly passes without being registered; but the realisation of all these conditions leads to such complication as to render it practically impossible to make such a meter at a moderate price.

CLOCK METERS.

Formerly clock meters had to be wound up; but now electric clocks are employed. Two perfectly distinct principles are applied to the construction of these meters. Either the current exerts an action on the clock's speed; or the clock has nothing to do but exactly determine the intervals at which special mechanism measures and registers the intensity of the current. Whatever be the principle adopted, however, its application requires complicated mechanism that can work exactly for a long period, while these meters are often cumbersome; and therefore they, too, cannot be made efficient for a moderate price.

ELECTROLYSIS METERS.

For securing this last-named desideratum complicated mechanism must be given up, which is possible by the use of electrolysis. The weight of matter deposited in an electrolytic jar is strictly proportional to the quantity of current that has traversed it. This principle has long been utilised in the construction of meters for continuous-current installations; but in practice serious difficulties are encountered, it being specially necessary to avoid too great a loss of voltage.

THE SCHATTNER ELECTROMETER

also depends upon electrolysis, while avoiding, however, the chief defects mentioned above. Sulphate of copper and copper electrodes are employed; and the indicator is a scale beam, which registers the weight of metal abstracted from the anode suspended from its end. There is only, in this electrolytic action, transport of copper between the electrodes, the solution undergoing no modification on that account, so that the loss of voltage is reduced to a minimum. The surfaces of the electrodes are very large, and the density of the current slight, so that a regular deposit is obtained.

ACCUMULATOR-CHARGING METERS.

In many electrical installations placed under the charge of inexperienced persons the accumulators are often damaged through deficient charge or over-charge; and to meet this difficulty a special type of meter has been made, that constantly shows whether a just measure has been observed in charging and discharging. Such a meter, which must evidently permit of a greater current during the charge than during the discharge, consists of an apparatus like an ordinary meter combined with an automatic interrupter that shunts a known and defined fraction of the current during the charge, so that as much copper is taken off the anode during the discharge as is deposited upon it during the charge, and the balance is in equilibrium when the charge régime is normal. With this apparatus, therefore, an inexperienced person can readily ascertain if he is charging, and to what extent, a set of accumulators.

ADVANTAGES OF THE SCHATTNER ELECTROMETER.

These meters are inexpensive, owing to their simple construction; and their maintenance is cheap and easy, owing to the absence of complicated mechanism. The copper plate, that costs 4s., need only be renewed after a consumption of 600 to 1,000 k.w.-hours. The loss of current occasioned by this meter is very slight—0·7 per cent. of the voltage when in action, but nothing at all when out of action; and it registers correctly to less than one-tenth of an ampère.

CENTRAL STEAM CONDENSATION.

THE laying down of central condensation plant is a matter of serious difficulty, especially when the volume of exhaust steam is very variable, as in the case of mines, owing to the intermittent working of the winding engines. It is not therefore surprising that the problem long remained without satisfactory solution; but in Germany the tendency is increasing, at works where there are a great many steam engines, to lead all the exhaust steam to a single condenser, while a cooling apparatus is generally added, which permits of using the same water over and over again. Thus remarks M. Henri Dechamps in his review of the mining machinery at the Düsseldorf Exhibition for the *Liège Engineers' Association*; and he continues that, according to the conditions of each case, the system of injection or surface condensation is employed. In the latter, the steam may be made to pass through several superposed series of pipes sprinkled with water falling in a cascade; or the pipes may be immersed in a basin traversed by a water-current. Again, the usual surface-condenser arrangement may be adopted — a group of tubes inside a cylindrical casing between two tube-plates, and traversed by a stream of cooling water, the steam to be condensed being led into the space round the tubes.

THE WEISS SYSTEM,

represented by G. Brinckman and Co., of Witten-on-the-Ruhr, is characterised by its adoption of the counter-current principle. The cooling water is admitted at one end of the plant, and the steam to be condensed at the other, the two currents passing in opposite directions, and their relative speed being equal to the sum of their absolute speeds. Moreover, the portions already cooled of the steam to be condensed encounter the coldest water; and as the latter becomes heated it comes into contact with steam of higher temperature. The air and the hot water are drawn off by two distinct appliances, the former in the smallest possible volume, *i.e.*, with a minimum expenditure of power. The plant comprises a vertical condenser, at the top of a pipe, 10 metres (33 feet) high, the lower end of which dips in a basin, while the general pipe leading the exhaust steam gives into the bottom of the condenser. On the contrary, the water-injection pipe terminates near the cover; and the cooling water is raised by a pump, not to the condenser, but to a tank some distance from it, though not too far for the water to accomplish the rest of its travel, owing to suction caused by the vacuum. The water then descends, meeting the steam, being divided into very thin sheets by baffle-plates; and the mixture which it forms with the condensed steam flows into the tank above which the condenser is placed, owing to the difference of level, that corresponds with an atmosphere of pressure. To the Weiss condenser is annexed a

BLASBERG COOLING APPARATUS,

which consists of a rectangular timber chimney, having at the bottom a Horden refrigerator, made of superposed slats covered with small pieces of basalt. A special pump raises the hot water from the condenser, which water is distributed over the whole surface of the refrigerator, being sub-divided by the pieces of stone into small drops, while the air drawn by the chimney draught passes across interstices in the stone beds.

BALCKE & CO.'S CONDENSATION PLANTS

are always on the counter-current system, whether a surface or an injection condenser be employed; and in the latter case, when local circumstances permit, the condenser is placed at a sufficient height above the discharge channel to render a hot-water pump unnecessary.

In the former case the exhaust steam passes from the collector to the oil-separator, generally cylindrical with vertical axis, containing three parallel vertical plates, punched with holes alternately at top and bottom so as to form baffles; and the oil collecting at the bottom is withdrawn by a special pump. The steam then continues to the surface condenser, supplied with cooling water by a circulating pump; and the air drawn along with the steam is taken off by a dry-air pump through a pipe starting from the highest part of the condenser, and provided with a small purifier for freeing it from any moisture, the bottom of this purifier being put in communication with the hot-water pump. All the pumps are worked off a two-throw crankshaft from a steam engine. This firm claims to have invented chimney coolers, the chief advantages of which are that their efficiency is independent of atmospheric movement, and that the dew or vapours are given off from them at such a height as to constitute no nuisance to the neighbourhood.

GOLD MINING AND GOLD-STEALING IN SIBERIA.

THE Russian review *Russkoe Bagatstvo* for September (August 30th), contains a very interesting article by M. Paul Bieletski on the methods of gold-mining practised in Siberia. M. Bieletski argues that the formalities and red-tape which at present make prospecting in Siberia almost impossible, should be replaced by a simpler system. At present prospectors have to undergo such a number of formalities, both before prospecting and after discovering gold, that only those with capital to risk, and those who evade the law, have a chance of carrying on the industry at a profit. Before setting out at all, the prospector has to obtain a stamped certificate giving him authority to prospect. This certificate he has to present at the local Government office, with his passport and a police certificate. If he wishes to do this quickly he must appear personally at the Mining Department. But this only begins the necessary formalities. When his party is formed, he must notify the district police office as to where he proposes to prospect, lodge a further copy of his certificate, and give full particulars as to names, passports, etc., of every member of his party. Before prospecting for gold he must mark off the five versts of river, or four square versts of land, where he proposes to search. But this gives him only a right to search for gold, and no right to work it. If he discovers any gold whatsoever, he is obliged to stop working, and even return the gold to the ground, until he gets the necessary authority to work it. This requires further reference to the nearest police office, sometimes a thousand miles away, and long delays, payments, and more detailed marking off of claims. This marking off must be done by a government official, who having travelled a thousand miles, must be lodged at the prospector's expense. Finally, every dwt. of gold must be registered in books. It is only after providing for all these formalities that the actual working of the deposits can be commenced But when work is begun it may very well happen that the deposits are so poor as not to be worth working; in such a case the prospector loses his time and money, and before attempting to work another claim he must repeat the formalities, perhaps only to meet with another disappointment.

The result of all this red-tape is that a very large proportion of Siberian gold is got by evasion of the law. The prospectors prefer to employ *khistchniki*, or uncertificated miners, mostly belonging to the criminal class, from whom they buy gold at much below its value. The certificated miners and prospectors complain much of the depredations of these *khistchniki*, but in reality they profit by their labour, as it is much cheaper to buy illegally worked gold than to work it under the present conditions. The Government, by means of Cossacks and police, carries on a continuous war with the uncertificated miners, a conflict sometimes attaining the dignity of pitched battles, but without result. The *khistchniki* form the advance guard of most regular prospecting parties, and owing to the lack of information as to the geological conformation of the gold districts, they as often as not discover gold-bearing land in shorter time than the regular prospectors. "The discovery of gold," says M. Bieletski, "is, to a great extent a matter of chance, the ignorant workman often being as successful as the skilled geologist." The prospectors therefore often make large fortunes by buying the "rights" to gold-bearing land discovered by vagabonds and escaped convicts. In conclusion, M. Bieletski argues that all the formalities which must now be undergone before actual working should be done away with, and that the right of prospecting should be open to all.

RUSSIAN SHIPPING AND CANAL PROJECTS.

THE project for constructing a deep-water port at Kertsch has been condemned by the Taganrog Committee of Trade and Manufactures, on the ground that, if Kertsch were selected as a central port for ocean-going ships, there would be a general decline of the Azov ports, resulting in serious losses for the rival ports of Taganrog, Rostoff, Mariupol, and Berdiansk.

The *Odessa News* urges the necessity of joining the White, Black, and Baltic Seas by means of canals, maintaining that, under no circumstances, should the work be allowed to pass into the hands of a foreign company. The *News* lauds the project as one "incomparably more useful for the Empire and people than the new railway across the Asiatic Continent."

The *Odessa News* gives particulars of a newly-formed Italian company which has entered into negotiations with the Russian Volunteer Fleet for the opening of regular communication by means of large steamers between the Black Sea and New York, the volunteer steamers to carry on freight and passenger traffic between Odessa and Naples, and to carry Italian emigrants from Naples to the United States. It is proposed at first to devote two volunteer steamers of the *Petersburg* and *Orel* class to this traffic. This project has been accepted favourably by the Volunteer Fleet, as the administration of the fleet had already been considering the advisability of extending the area of their operations.

LINE FROM MOSCOW TO BE RELAID.

The Russian Minister of Ways of Communication has raised the question of increasing the speed of the express trains from Moscow to Western Europe to a rate of 65 versts an hour. The directorate of the Moscow-Brest Railway, after considering the question, replied that with the present permanent way the present speed of 50 versts an hour cannot even be maintained, and that the whole line must be relaid with rails of the officially recognised weight of $28\frac{1}{2}$ lbs. to the foot. This change is to be completed within four years, at a cost of 20,000,000 roubles. Meantime, the speed of the express trains is to be reduced to 44 versts an hour, increasing the journey between Moscow and Brest by $1\frac{3}{4}$ hours.

NEW CIRCULAR RAILWAY AT MOSCOW.

In Moscow the preparatory works for the new City Circular Railway, the plan of which was approved by the Emperor in March, are being pushed forward. The surveys are completed, and M. Rashevsky, the engineer in charge, proposes to begin construction this year. The estimates for the railway amount to 40,000,000 roubles, and it is expected the new line will be opened in 1905. In view of the fact that the circular railway will supply only the suburbs, while the centre of the city will be cut off as before, M. Rashevsky has put forward a project for the construction of a municipal diametrical line on the model of Buda-Pesth city railway. The cost of such a railway in Moscow is estimated at 25,000,000 roubles.

RUSSIAN RAILWAY PROJECT REVIVED.

THE St. Petersburg *Courier* announces that the old Russian project of building a railway from Central Asia to Siberia is on the point of realisation. A private company of Russian and foreign capitalists under the leadership of Mr. S. I. Mamontof has been formed with the approval of the government. The line will start from the town of Turkestan, intersect the Siberian Railway near Tomsk, and be extended to the north to a point not yet determined. The railway is to supply the needs of the rich grain-growing districts in the south of Tomsk Government, Biisk, Barnaul, Altai, and the Semipalatinsk Oblast. Trade between Tomsk and Northern Siberia is to be carried on by steamers on the Tom and Obi, but in view of the defects of the Gulf of Obi it is proposed to build a line from Obdorsk, near the mouth of the river, to some more favourable port on the Arctic Ocean. These constructions will complete communication between Central Asia and the Arctic Ocean. The estimated cost is 150,000,000 roubles, or half the first estimated cost of the Great Siberian Railway.

SOME BOOKS OF THE MONTH.

"A HISTORY OF WIRELESS TELEGRAPHY."

Including some bare-wire proposals for subaqueous telegraphs. By J. J. Fahie, M.Inst.E.E. William Blackwood and Sons. 348 pp. 6s.

IN this interesting work, which now appears in its third edition, Mr. J. J. Fahie has afforded the electrical student much valuable information. The experiments of those inventors who first conceived and carried into practice the idea of space telegraphy are described, and the achievements of modern inventors carefully detailed. Events move rapidly in the electrical world, and thus it was found that the first edition of this history, in view of recent researches, required to be brought more into line with modern developments. To Mr. Fahie's work, therefore, was added a survey of the advances made in "wireless" telegraphy up to the beginning of 1901, when the second edition appeared. In the frontispiece are grouped the portraits of those whom the author aptly terms "the Arch-builders of Wireless Telegraphy."

At the top stands Oersted (Denmark), who first showed the connection between electricity and magnetism. Then follow in order of time Ampere (France), Faraday (England), and Henry (America), who explained and extended the principles of the new science of electro-magnetism. Then come Clerk-Maxwell (England) and Hertz (Germany), who showed the relation between electricity and light, the one theoretically, and the other by actual demonstration. These are followed by Branly (France), Lodge (England), and Righi (Italy), whose discoveries have made possible the invention of Marconi. The last three are portraits of Preece and Willoughby Smith (England), and Marconi (Italy), who divide between them the honour of establishing the first practical lines of wireless telegraphy—each typical of a different order.

As has been pointed out in recent articles on this subject, there exists much popular misconception as to who was the "real inventor" of "wireless" telegraphy, and this Mr. Fahie's book has done and will do much to remedy. Ample recognition is given to the significance and importance of the labours of Sir William Preece and Mr. Willoughby Smith, and the interesting record of their researches forms a fitting preface to a description of Signor Marconi's world famous experiments. In the appendices we have various papers and reports of lectures by Sir Oliver Lodge (on the relation between electricity and light, before and after Hertz), Professor Henry (on high-pressure electricity being confined to the surface of conducting bodies, and, modern views with respect to the nature of electric currents), and Professor Edouard Branly (on variations of conductivity under electrical influence), with a description of the remarkable researches of Professor Hughes, F.R.S., in electric waves and their application to "wireless" telegraphy, which he conducted during the years 1879-1886. These are followed by a reprint of Signor Marconi's patent, with plans, which should prove of special interest to readers of the article on Signor Marconi's inventions appearing in this issue. Various diagrams help to elucidate the text, and an exhaustive index renders the volume valuable as a book of reference. The work is dedicated to Sir William H. Preece, K.C.B., F.R.S., "as a slight token of esteem and friendship, and in acknowledgment of many kindnesses extending over many years."

"MODERN IRON FOUNDRY PRACTICE"—PART I.

By George R. Bale, A.M.Inst.C.E. Technical Publishing Co., Ltd. 387 pp. 5s. net.

THIS useful little manual, of which another volume will be published, is designed to meet the existing need for a comprehensive work that will give the student all available information concerning the foundry and its products. Part I. deals with foundry equipment, materials used, and processes followed, describing the furnace itself, the cupola and its charge, cranes, hoists, etc., and the various methods of moulding and casting. Machine moulding and kindred subjects, however, have been left to be dealt with in the second part, which will also include chapters upon physical testing, shrinkage and distortion of castings, the various methods of cleaning castings, foundry costs, etc. In an introduction to the work the author points out that the foundry can hardly be said to have kept pace with the rapid advances made of late years in most departments of the iron and steel industry. But the near future will see the culmination of the present growing tendency towards specialisation, when every shop and every workman will be confined strictly to a particular class of work, and there will be no foundries for general work. "Moulding machines will be employed in greater numbers and variety, adapted to the work; the purchase of pig-iron by analysis will become universal, and foundries will be better equipped with suitable appliances for transporting the cupola charges and the molten metal, a system of narrow-gauge tracks extending throughout the entire works."

It is suggested that there is much room for improvement in regard to the methods of casting, and in this connection the author advises the use of the camera to record the successive stages during the progress of any unusually difficult piece of work, so that in the event of its having to be repeated at some later date, the method previously employed may be inspected and followed, or possibly improved upon. The various processes and plants are efficiently illustrated by over 200 views and diagrams, and a methodical index adds to the value of the book.

"THE AUTOMOBILE: ITS CONSTRUCTION AND MANAGEMENT."

Cassell and Co., Ltd. 608 pp. 10s. 6d. net.

THIS handsome work is taken from the French of M. Gérard Lavergne's "Manuel Théoretique et Pratique de l'Automobile," but it is something more than a mere translation, Mr. P. N. Hasluck, the editor, in an endeavour to give the public a thoroughly up-to-date treatise, having re-written the original book throughout in a more condensed style, and introduced a large amount of entirely new matter, descriptive of mechanisms that have made their appearance during the last year or so. In an exceedingly interesting and practical manner, Mr. Hasluck has thus succeeded in presenting all that is known concerning motor vehicles of every kind. The book will show the engineer how the mechanism with which he is familiar is applied in motor construction, how the technical difficulties arising from this novel application may be overcome, and what yet remains to be done in this rapidly-growing industry. After a brief historical sketch and detailed consideration of the various motive agents, a description is given of the methods of determining the requisite horse-power and its transmission to driving wheels. Axles and steering gear, wheels and tyres, springs, under-frames and bodies, brakes and lubrication are dealt with in separate sections; and this analysis having been made, the elements are grouped according to the chief types of existing cars. Then the notable results, officially or otherwise confirmed, are recorded, and finally attention is directed to the lines on which progress in the direction of increased efficiency is to be sought. In this connection we learn that in the petrol car improvements will be secured by the better employment of the carburetted mixture, thus eliminating to a large extent the unpleasant smell; by the obviation of the necessity for using cooling water, and by rendering starting easier. The efficiency of transmission needs to be increased, and should be made the subject of comparative experiments. Not more than 6 or 7 per cent. of the energy of petrol spirit is actually burned to account; but even this rate of efficiency is greater than that of the steam car, which is (adopting 1·5 kilogrammes as the consumption per effective horse-power-hour) only about 5 per cent. "Certainly," we read, "cars now regarded as the most improved will, in the course of twenty years, be looked upon as being barbarous." In conclusion we read :—

> What remains to be accomplished in the construction of automobiles should not prevent a recognition of the importance of what already has been done in the most [illegible] [illegible] disorder in the ignition system, a hitch in the working of the pump, punctured tyre, etc., all these being so many [illegible] set right. The mistrust of the public, caused by the imprudence of some individuals, soon must be dispelled, and then automobilism will be safe and economic and enter completely into the customs of the day.

The book should prove of exceptional value and absorbing interest to all who own automobiles or who are engaged in the motor industry. The many examples of motors and their component parts are efficiently illustrated by 506 line engravings, and the printing and general get-up leave little to be desired.

NEW·CATALOGUES AND·TRADE PUBLICATIONS

These catalogues may be had free of charge on application to the firms issuing them. Please mention PAGE'S MAGAZINE when you write. Manufacturers of Engineering and Electrical Specialities, etc., etc., are invited to forward for review in this column copies of their catalogues, price lists, and circulars, as soon as issued.

The Richards London Machine Tool Company, Laurence Pountney Hill, London, and Paris. Section A, 1902.—A booklet of 50 pages and cover with an illustrated index and price list of their general catalogue of machine tools. The first portion treats exclusively of the new 1901 Patent Open-side Planing Machines, which they claim to be the most noteworthy development in modern machine tools. The machines are made to plane from 28 in. to 30 ft. long, and from 12 in. to 48 in. wide, and by the use of the "extension arms" to 60 in. wide. Some eight or ten drawings illustrating practical examples of the application of the machine are specially interesting, and we must express our appreciation of the excellent half-tone blocks with which the catalogue is profusely illustrated. At the end of the book is given a list of telegraphic words, which will be useful to foreign buyers.

The British Thomson-Houston Company, Ltd., Rugby.—Pamphlets Nos. 130, 131, 132. The first deals with their Type CE Continuous Current Stationary Motors, which are built for slow speeds, in sizes ranging from 2 to 15 h.p., and for moderate speeds in sizes from 3 to 20 h.p. The motor is symmetrical in form, and may be quickly arranged to run in an upright, inverted, or semi-inverted position. It may therefore be installed on the floor, ceiling, or wall. Pamphlet 131 deals with the Reavell Patented Duplex Type of Motor-driven Air Compressors, which are fitted with relief valve, drain-cock, and outlet connection screwed 1 in. gas. The motor runs at about 1,200 revolutions per minute, and drives a compressor at about 400 revolutions per minute, through gear wheels. The machine is designed for delivery pressures up to 30 lbs. per square inch, and only occupies a space of about 30 in. by 30 in. by 16 in. Pamphlet 132 describes the GE 58 Traction Motor. This motor is so designed and constructed as to be suitable for both narrow and standard gauges, with a minimum width of 3 ft. 3⅝ in., and is intended, for comparatively heavy service. Accompanying the pamphlets is a leaflet, with prices of their Direct Current Type CE Shunt Wound Motors.

Standard Engineering Company, of Leicester and Kettering.—An illustrated pamphlet of eight pages, describing their blowing and exhausting fans, including drawings and a table showing the various dimensions in inches. Their principal specialities appear to be right-hand and left-hand blowing and exhausting fans, both bottom, horizontal, and up discharges. The table above mentioned, though the figures are only approximate, is a very useful adjunct.

The Combination Metallic Packing Company, Ltd., of Gateshead-on-Tyne.—A well-designed catalogue of twelve pages and cover, printed in four colours, dealing with the principal speciality of this firm—viz., metallic packings. We are told that the packing is designed to suit either horizontal or vertical engines, is suitable for all speeds, self-adjusting as to wear, and, "once fitted, is no trouble to those in charge of the engine." A list of well-known names in the engineering world is given as an indication of the popularity of these packings, and, we understand, 80,000 sets, or an aggregate of 3,000,000 h.p., have already been fitted. The sectional drawings showing the different modes of application are exceptionally interesting.

Toope's Asbestos Covering Company, Ltd., Stepney Square, London, E.—A catalogue and price list, of twenty-four pages and cover, dealing with the "Toope Patent Pure Asbestos," the "Toope Patent Hair-felt Coverings," their "Asbestos Infusorial Silicate Plastic Composition," and a silicate papier-maché non-conducting composition, for covering or coating steam boilers steam pipes, hot-air or blast pipes, cylinders, superheaters, and vacuum pans; also for protecting water-pipes, tanks, etc., from frost. For the asbestos many advantages are claimed, the principal of which is that it acts as a perfect non-conducting medium between the steam pipes and the atmosphere, and prevents the radiation of heat and condensation of steam in its transit from boiler to cylinder. Another interesting speciality is their non-conducting removable coverings, which are made in sections, 3 ft. long, to fit on pipes any diameter, from ½ in. to 2 ft., and from ¾ in. to 6 in. in thickness.

The Hughes-Johnson Stamping, Ltd., Langley, Birmingham.—This is a neat little booklet, entitled "Drop-forgings," describing and illustrating their various specialities in steel manufactures, viz., weldless eye-bolts of many designs, bow nuts, weldless wrought steel swivels, machine spanners, lathe carriers, shaft collars, lathe chuck jaws, level and handle ends, hooks of various kinds, and a variety of automobile forgings. Particular attention is called to their roller boiler tube expander, which, it is claimed, can be used where it would be difficult or impossible to use the ordinary tool; and an additional advantage is that one of the tube expanders can be adapted to tubes of several sizes.

The Library Supply Company, 181, Queen Victoria Street, E.C.—We have been favoured with some advance sheets of a new catalogue which this firm will shortly issue, and if the collection before us may be taken as a fair criterion, the completed catalogue will reflect much credit on its designers. The principal speciality of this firm is the manufacture and supply of up-to-date office furniture, special attention being given to the fitting and furnishing of town halls and public buildings, libraries, museums, technical schools, insurance offices, banks and business offices generally. Another speciality worthy of notice is the card-system, and a particularly interesting illustration shows a double-desk cabinet for cost records. This, in addition to 24 ordinary drawers, has 104 slide trays, and affords capacity for 190,000 cards. The card-system is very highly spoken of as a simple labour-saving device, and applied to the indexing of correspondence, drawings, special tools, etc., is proving itself an indispensable adjunct to the office equipment of the engineer.

Andrew Handyside and Co., Ltd., Britannia Ironworks, Derby.—Catalogue C.—This is an illustrated book of designs for fountains and vases cast in iron and bronze, and costing from £1 to £1,200. The Britannia Ironworks, Derby, is, we are told, one of the oldest foundries for this purpose in England. The cover design is one of exceptional merit. A striking combination of light and shade is heightened by the novel colour scheme. The artist shows a model fountain, the amber waters of which are sharply outlined against a background of black and olive green, introducing a terrace and parterres. The trees beyond are silhouetted in black, and the artist has cleverly rendered the sparkle of the water from the fountain. White is employed only for the words "Fountains and Vases—Handyside," which are thus made to stand out incisively without detracting from the design. There are also some particularly fine inset plates, drawn to scale, illustrating to great advantage some of their magnificent ornamental cast iron and bronze work in fountain vases, and the drawings both of these and fountain-head and basin designs, as well as the ornamental garden vases, of which there are some thirty examples, are particularly interesting. Altogether a very useful catalogue, and one from which much useful information as to the cost and mode of fixing fountains can be obtained.

Babcock and Wilcox, Limited.—A second edition of their interesting work on "Patent Water-Tube Marine Boilers" has just come to hand. The subject matter embraces articles such as The Water-Tube Boiler: Its Status; Requirements of the Marine Water-Tube Boiler; Description of the Babcock and Wilcox Boiler; Comparison with Shell Boilers; Re-boilering U.S. Monitors; Notes on Corrosion: Causes and Preventative Measures; Points of Interest in connection with Vessels fitted with Babcock and Wilcox boilers, etc., and includes a large quantity of most valuable data obtained from trials of Babcock and Wilcox boilers on shore and at sea. The record of Babcock and Wilcox boilers in American war vessels during the late war with Spain appears to be of exceptional merit, and forms a striking commentary on the statement so frequently made in the Press that water-tube boilers are unreliable and exceedingly costly in repair. A perusal of the article on corrosion and the accompanying tables should be helpful to every sea-going engineer. The subject is very clearly treated, and a description given of an apparatus supplied to all ships in which Babcock and Wilcox boilers are installed for determining chemically the amount of chlorine, if any, in boiler water. The book is profusely illustrated, and many of the plates are of a high order. It is well printed on art paper, and is bound in green cloth. The pages have ample margins and are clearly arranged, and the volume, apart from its technical value, is a valuable addition to the library.

Howard Bros., Liverpool.—An illustrated catalogue and price list of twenty pages and cover, describing in "pithy" style the use of the "Dey" Time Register, which we understand has lately been considerably improved by various additions and alterations. This Time Register is made in different sizes for accommodating fifty to two hundred employees. It prints the exact minute in a very convenient form on a paper sheet inside the machine, which cannot be tampered with. Each record is separate and complete in itself, and no matter in what order the employees come in or go out, their numbers are bound to appear in consecutive order on the time slip, with all the registrations for day or week (as the case may be) printed in bold type, giving the exact hour and minute at which they register, in one line opposite each man's number. A concise time sheet is thus furnished, showing a complete record at a glance. Several highly commendatory letters from customers of many years' standing are reproduced. That the machine is very simply constructed is demonstrated by a half-tone illustration of its interior. It is consequently blessed with almost complete immunity from the vexatious and oftentimes costly irregularities to which complex mechanism, in all forms, is so liable.

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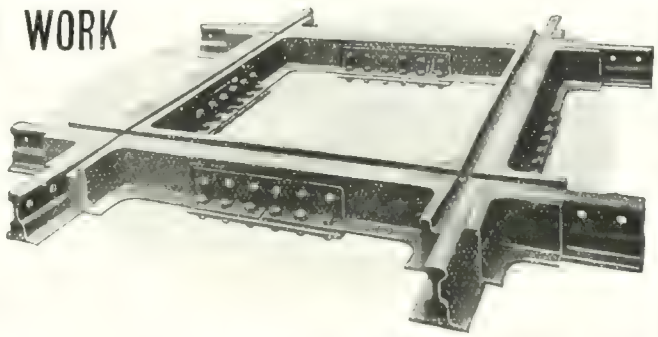

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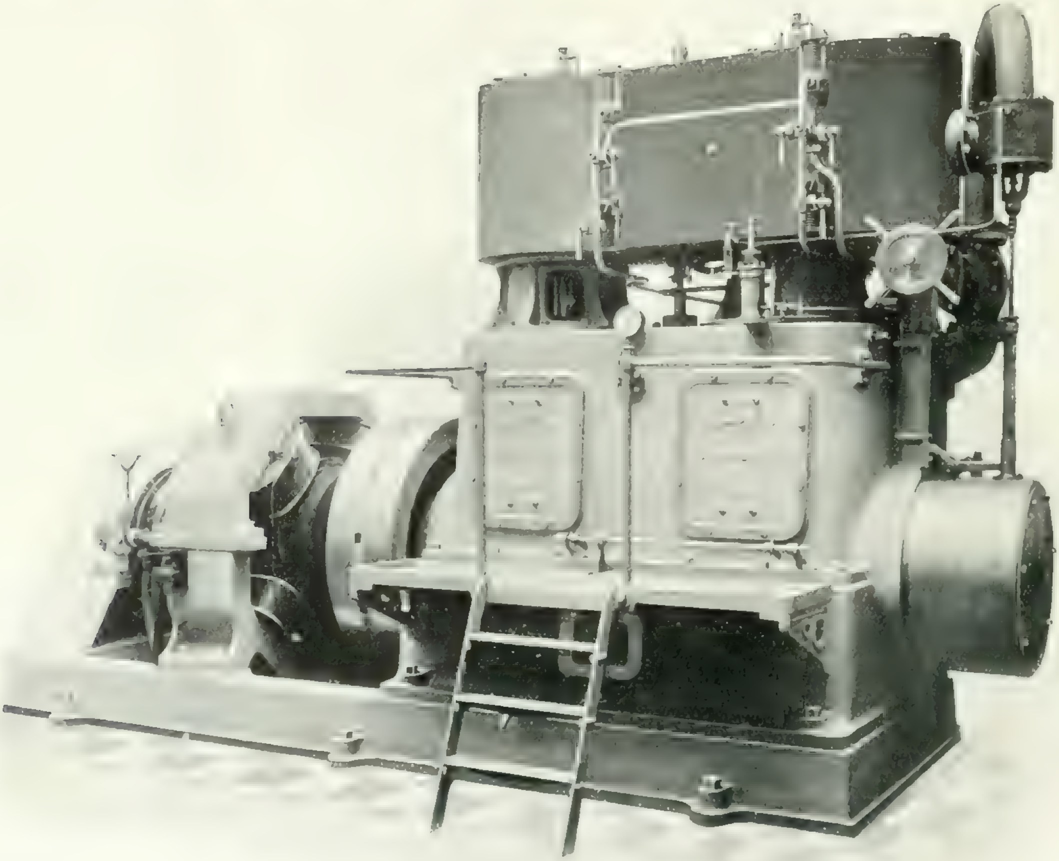

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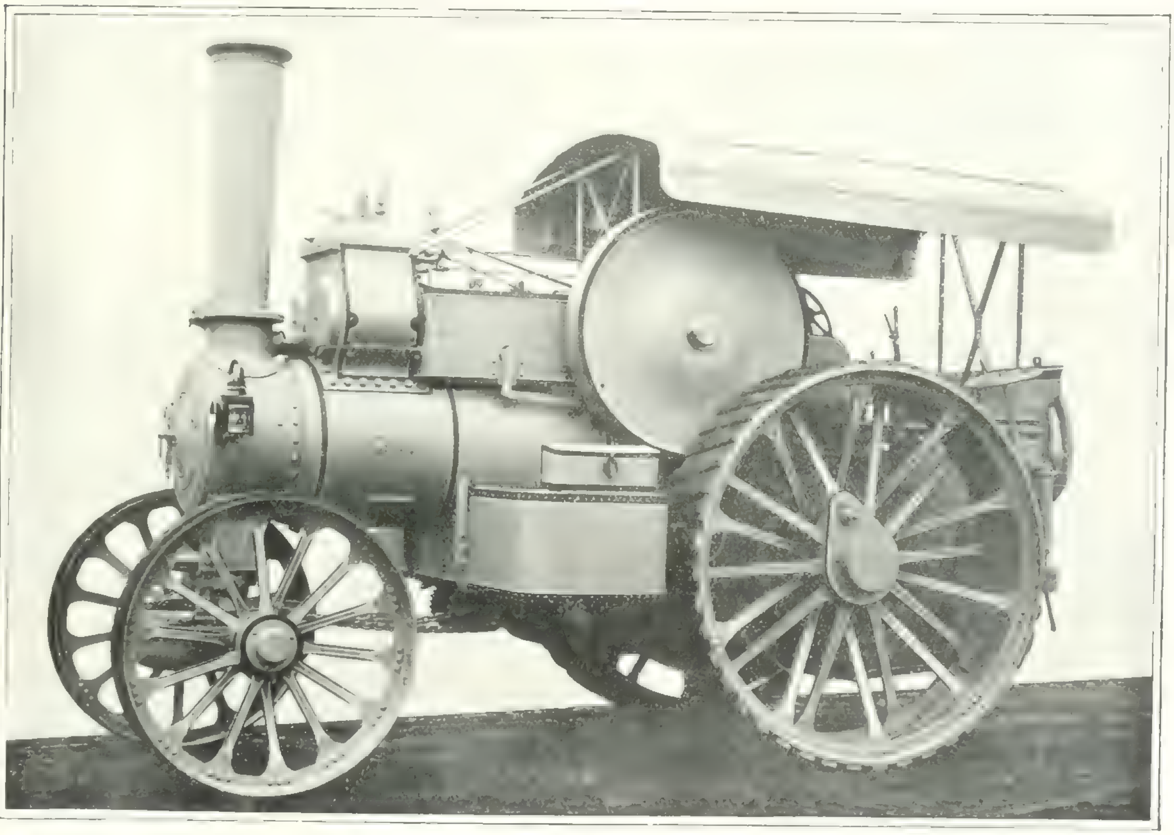

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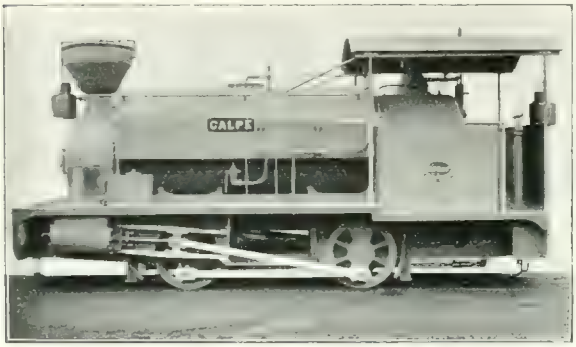

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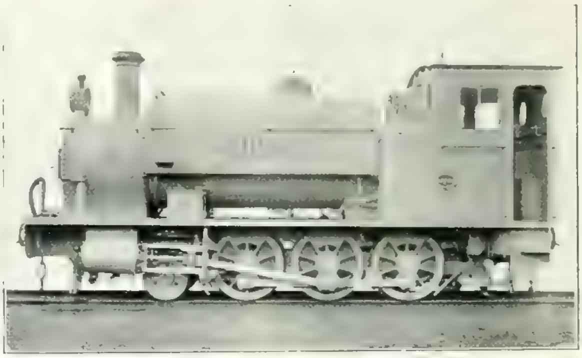

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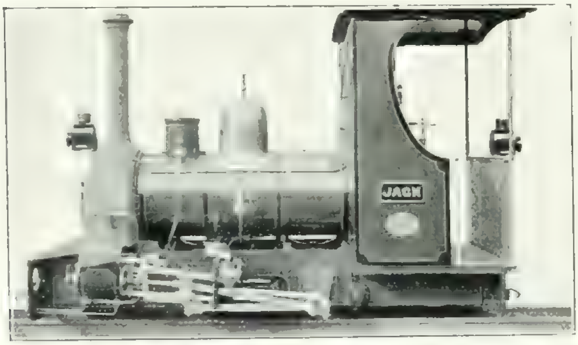

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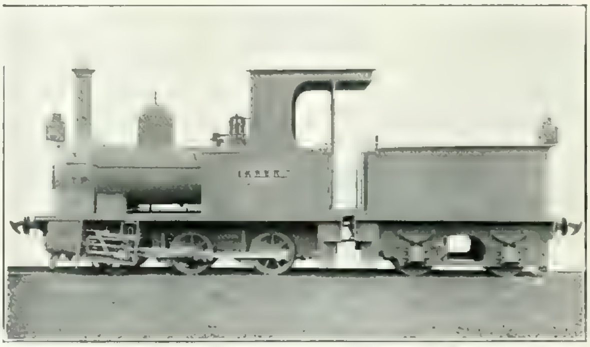

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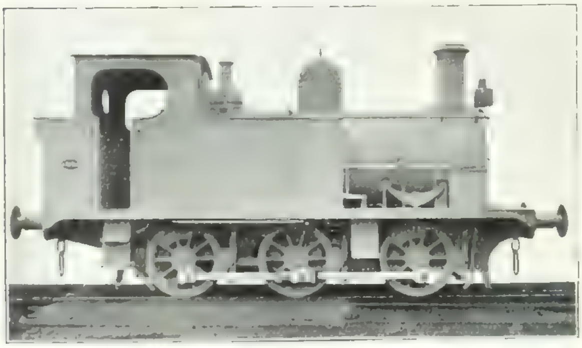

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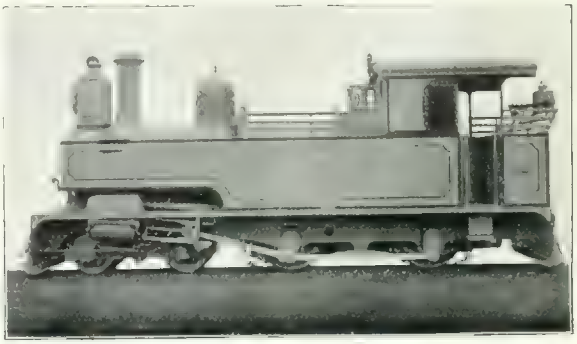

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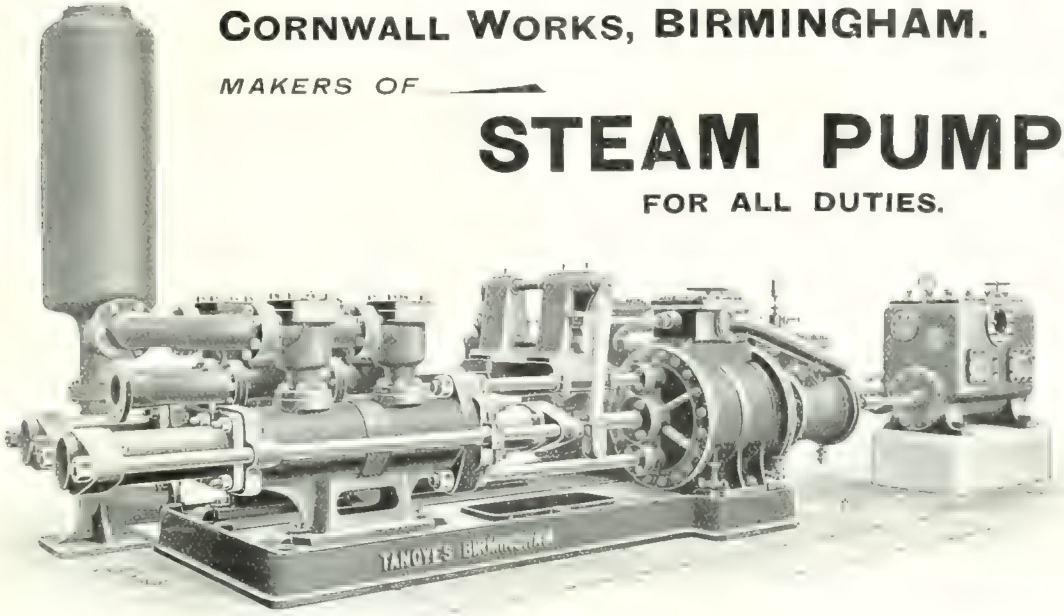

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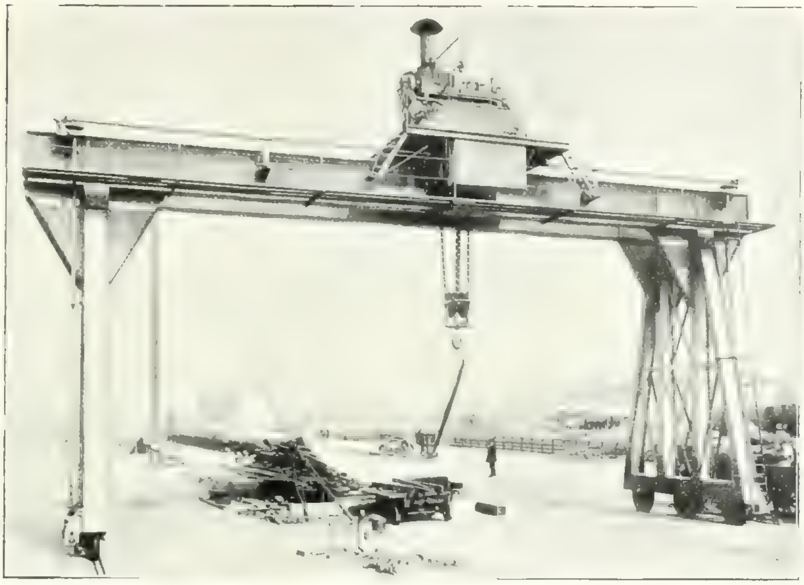

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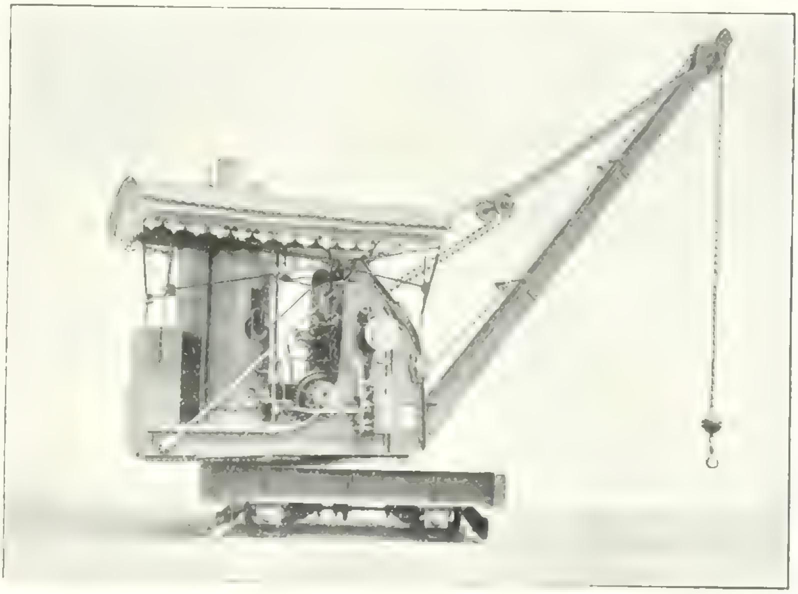

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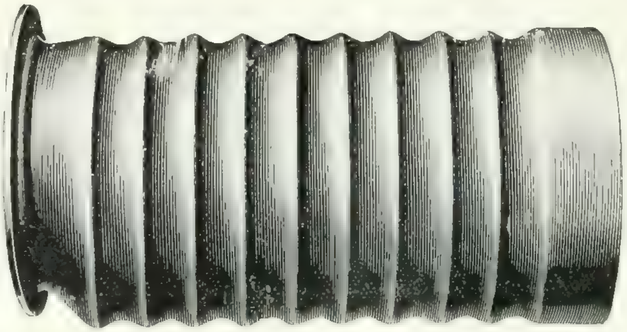

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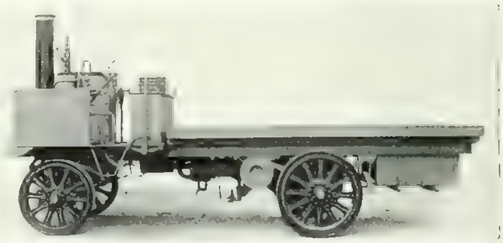

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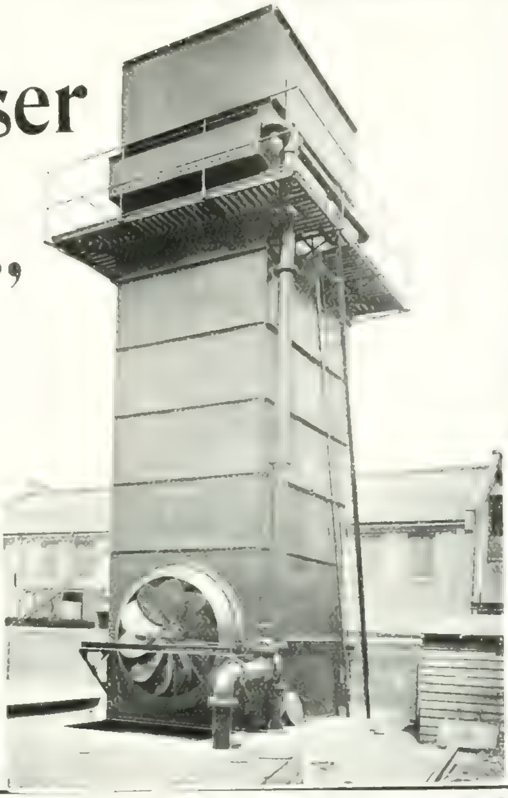

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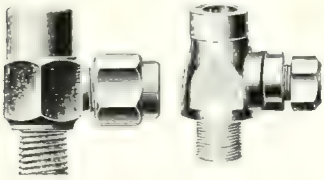

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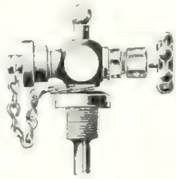

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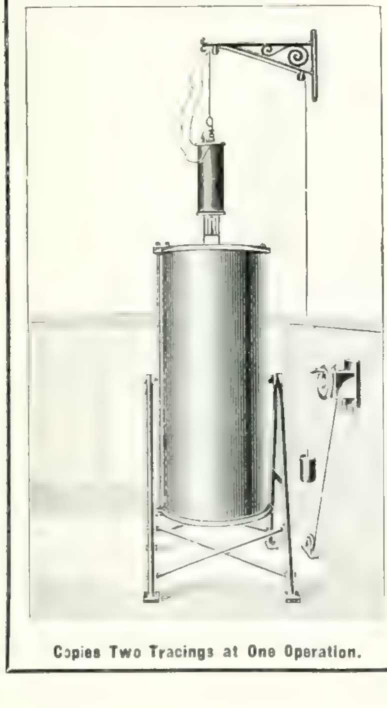

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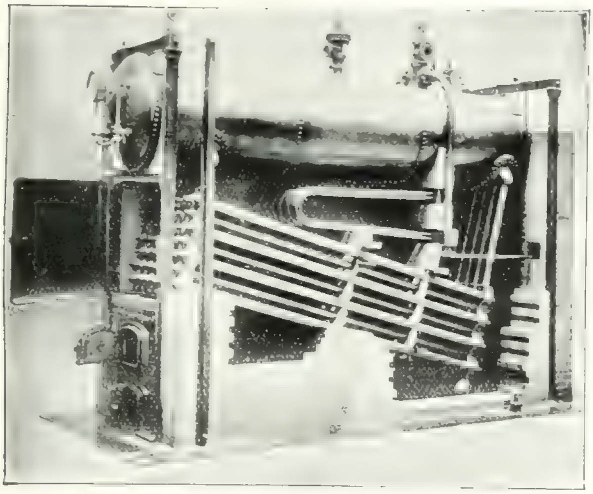

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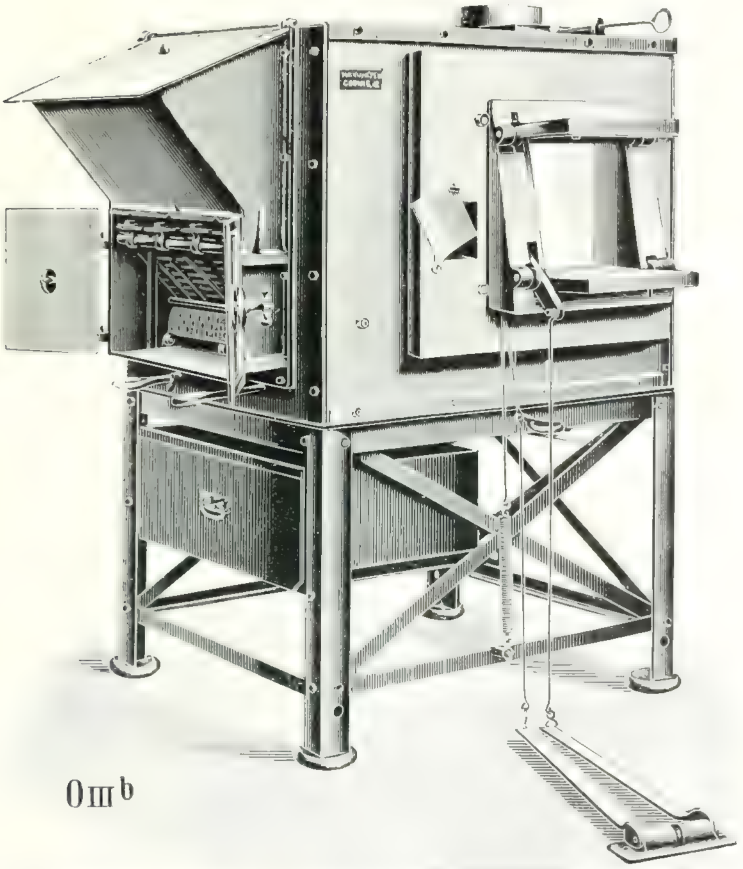

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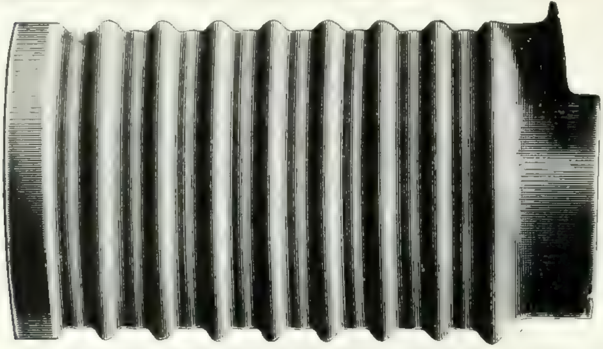

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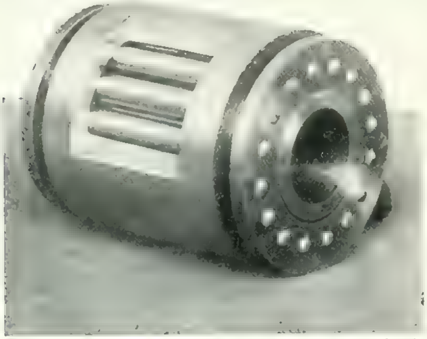

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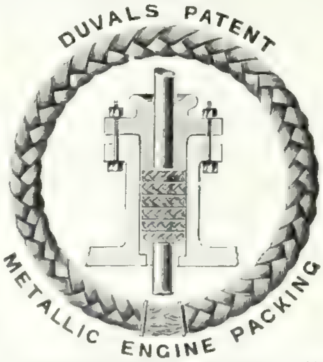

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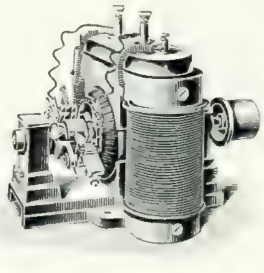

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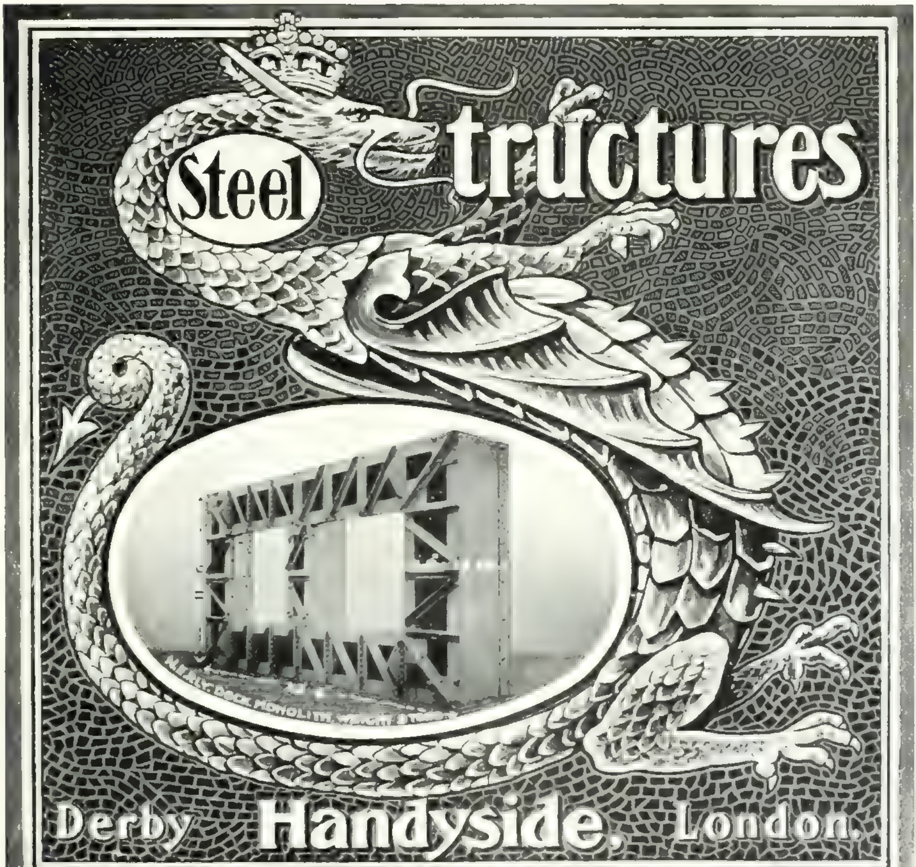
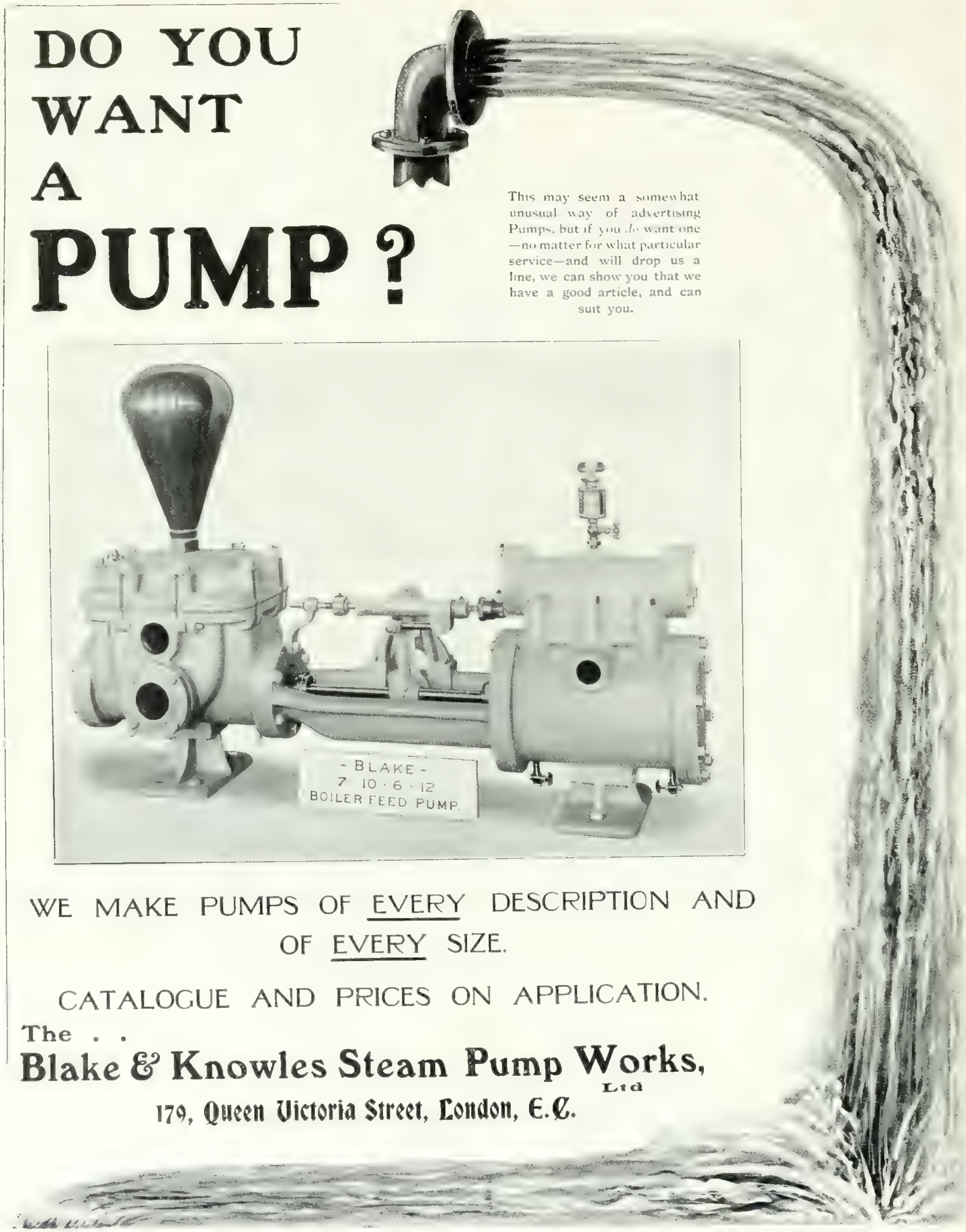

Steel
tructures
DOCK MONOLITH, WEIGHT
Derby
Handyside,
London.



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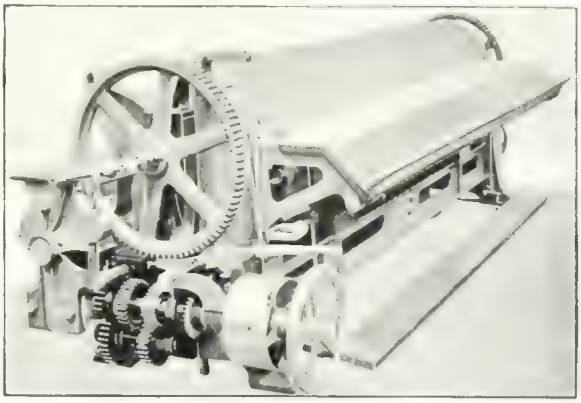
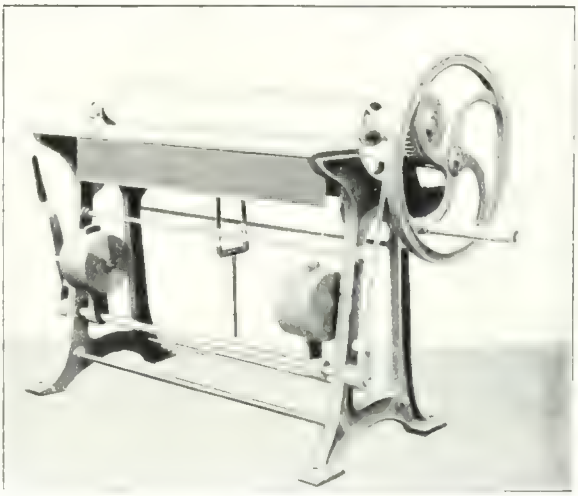
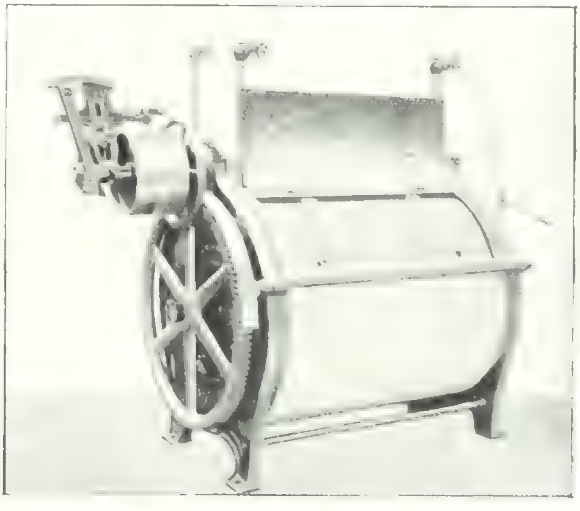


Ironing and Finishing Machine



Ironing Machine



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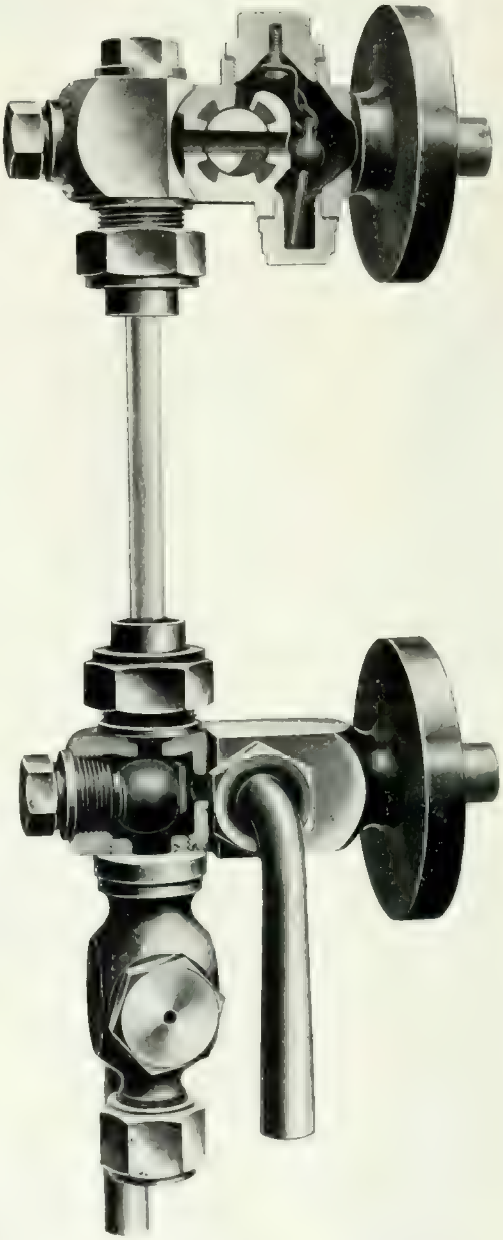

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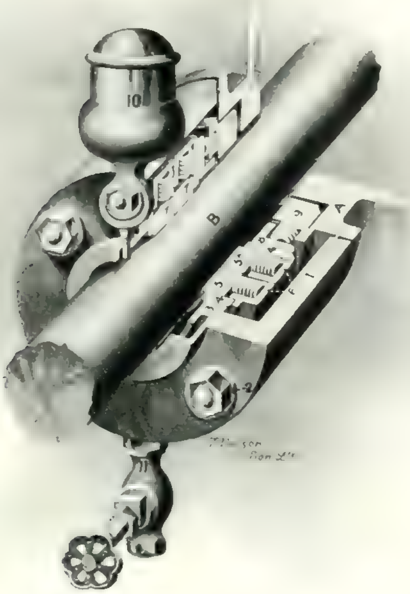

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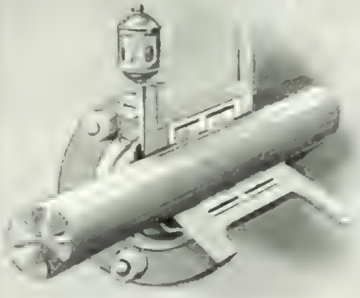

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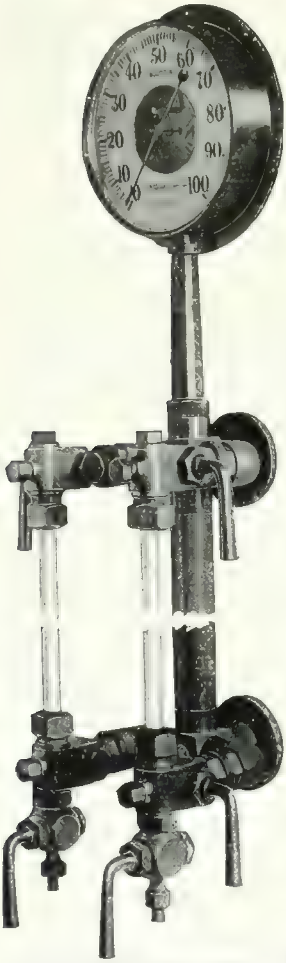

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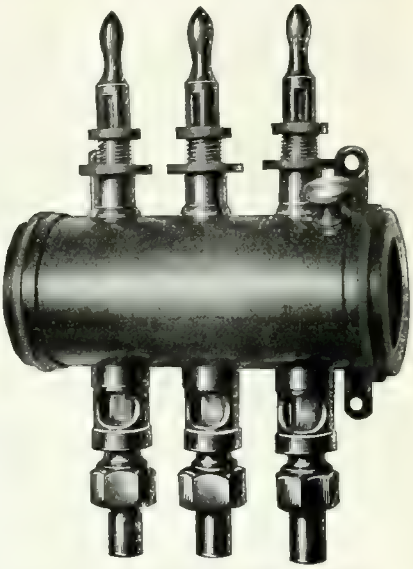

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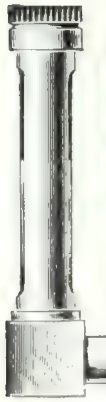
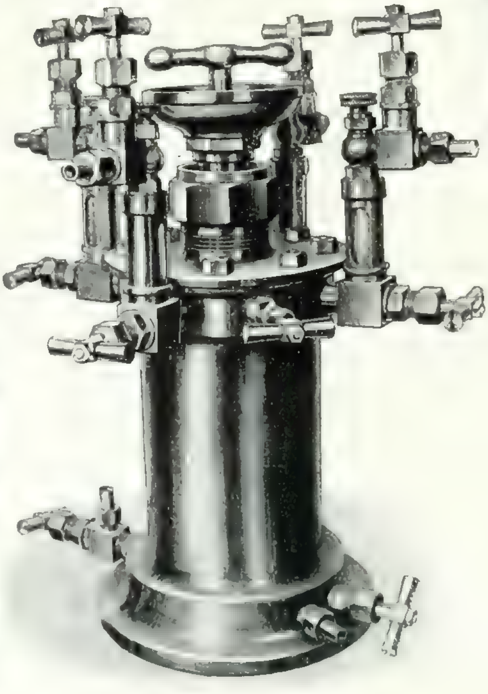
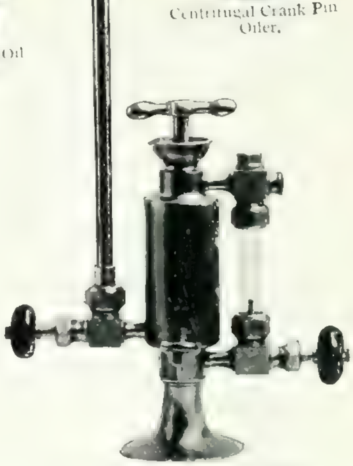


Oil Gauge Indicator for Sealed Bearings



Steam Cylinder Grease Cups



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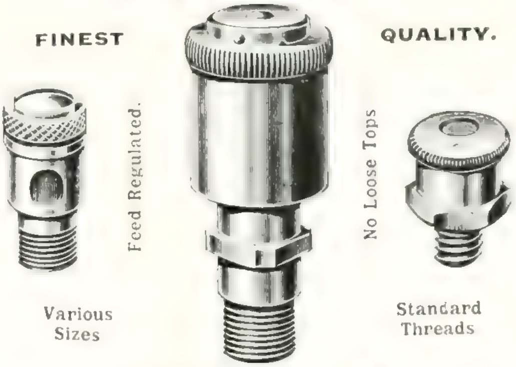

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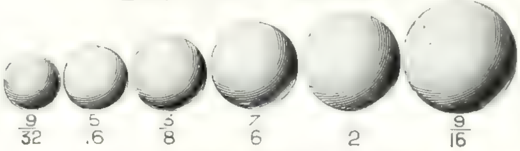

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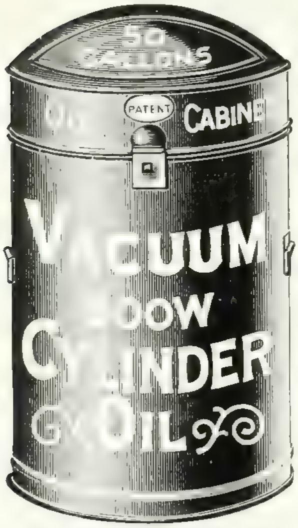

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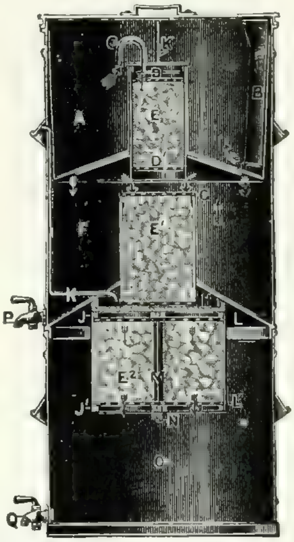

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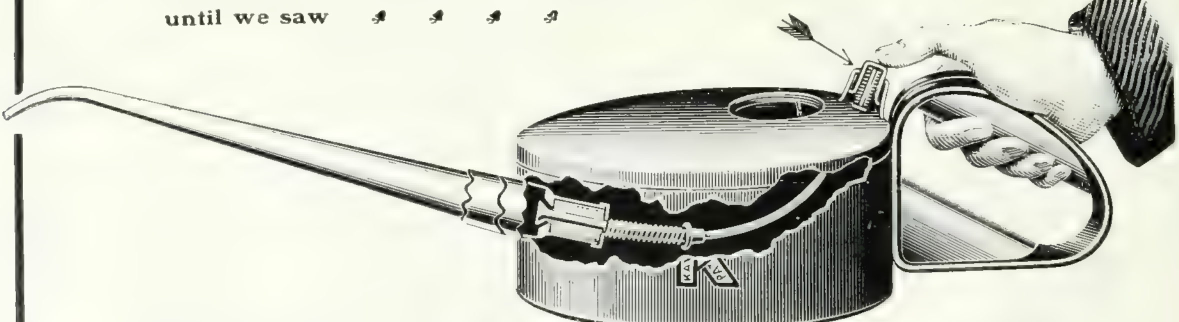

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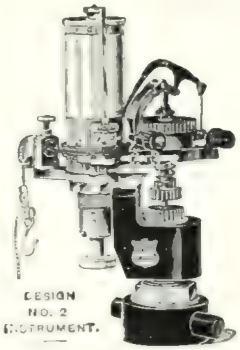
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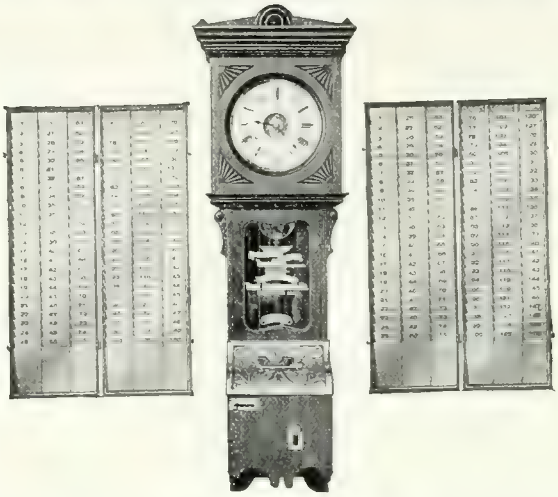

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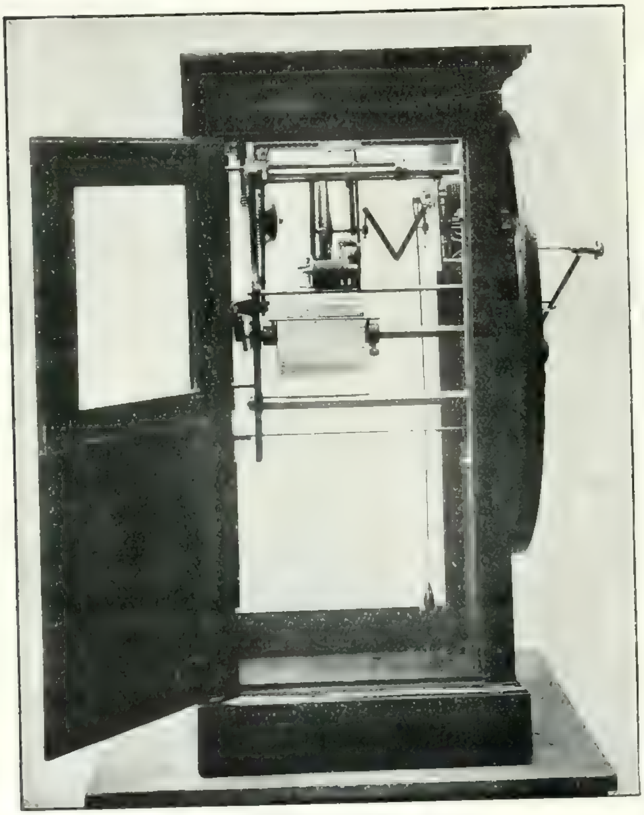

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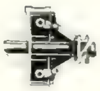

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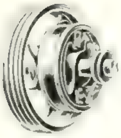

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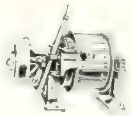

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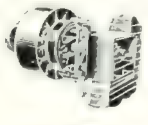

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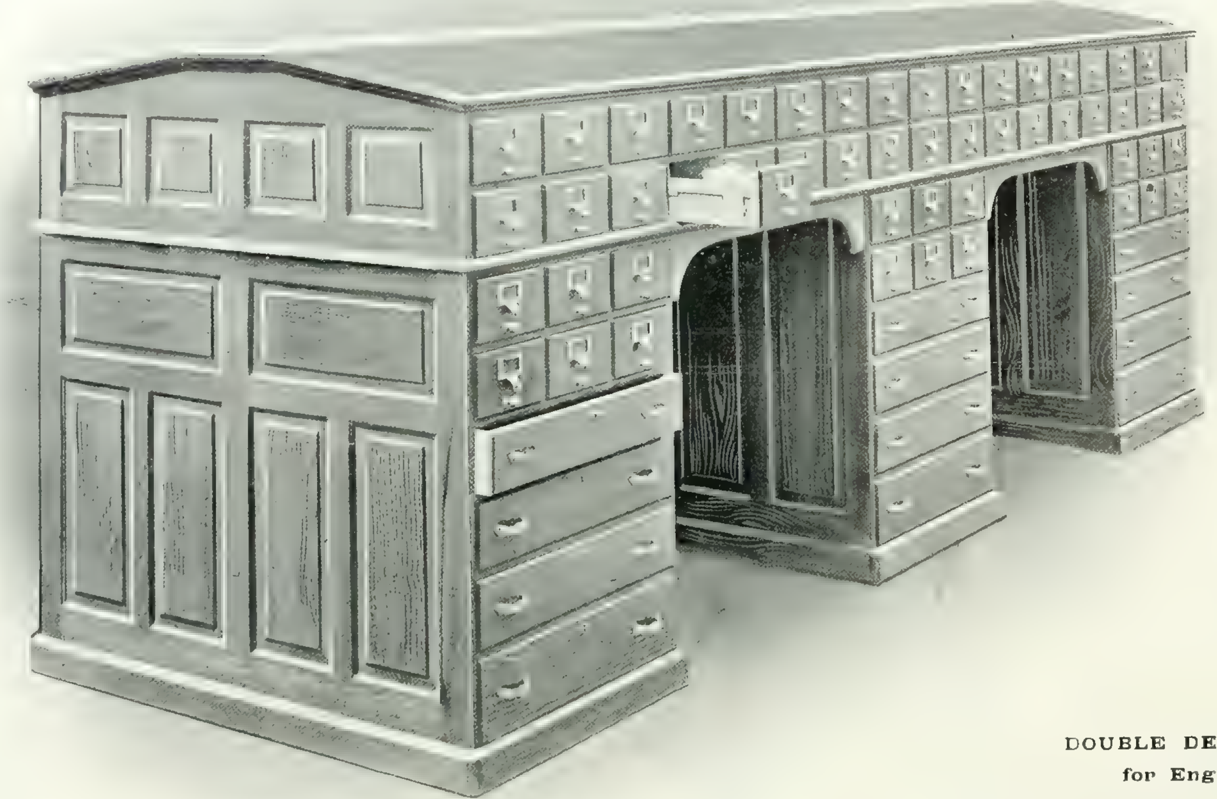

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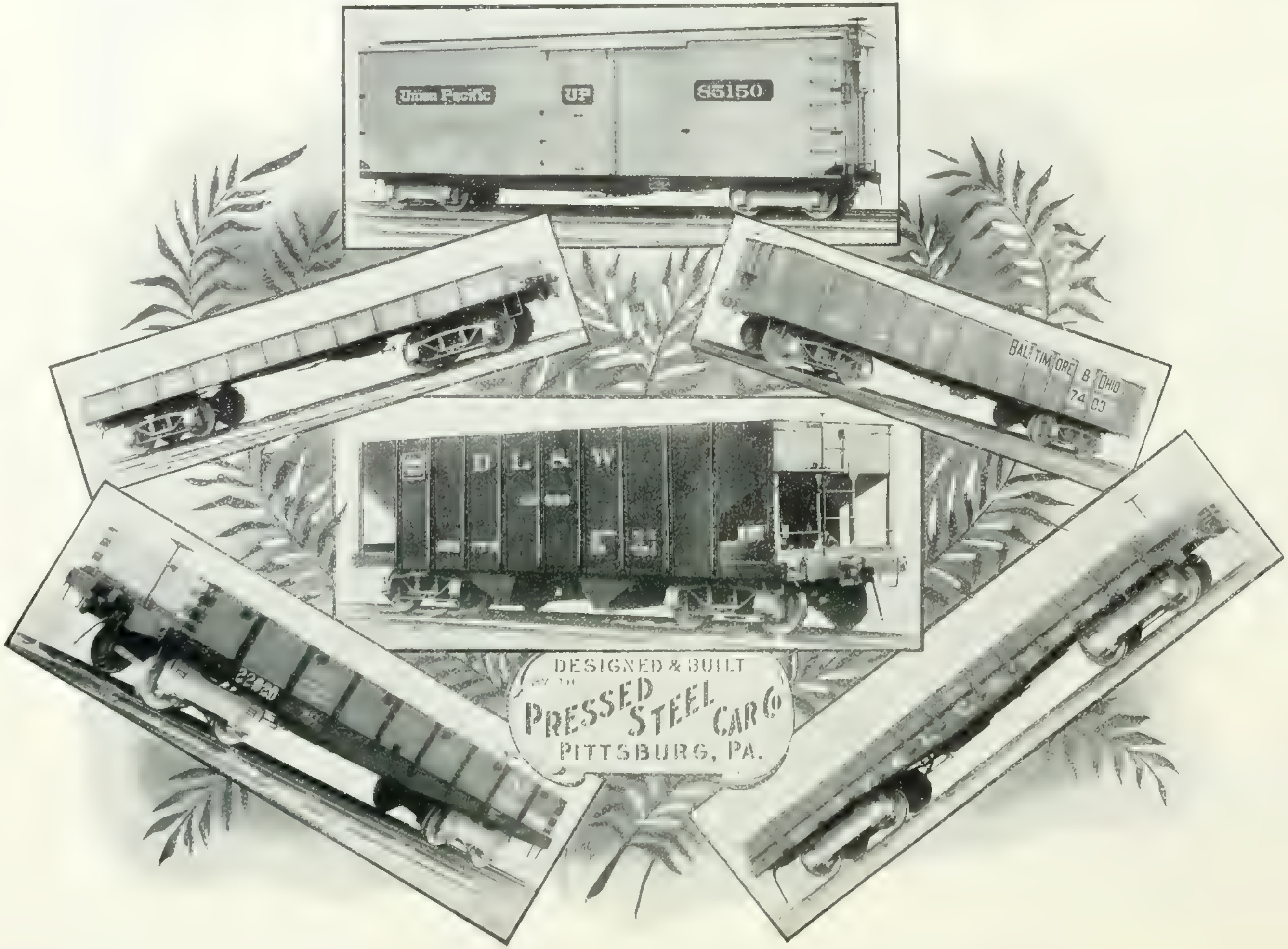

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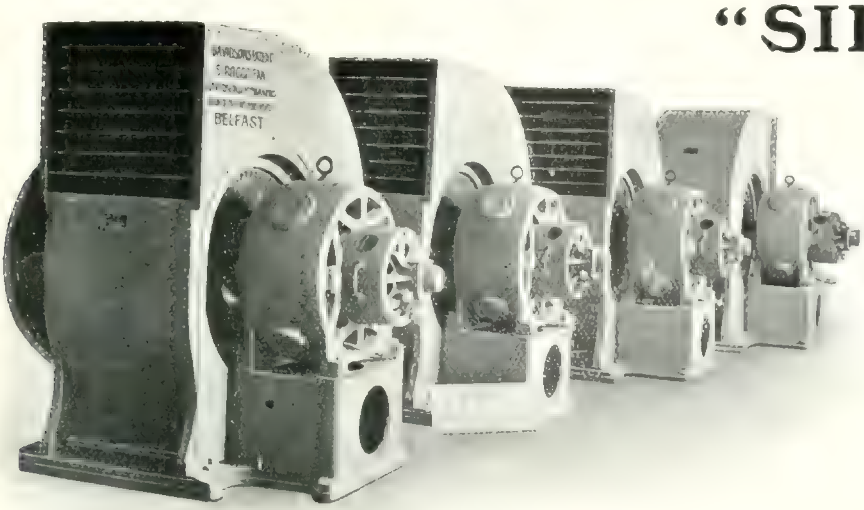

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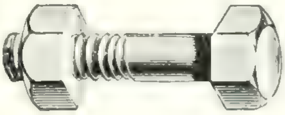

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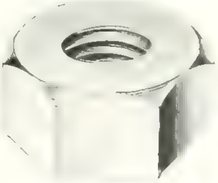

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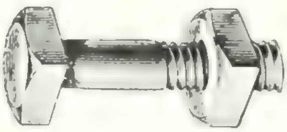

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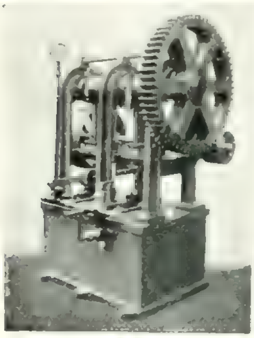

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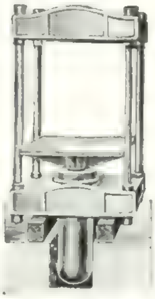

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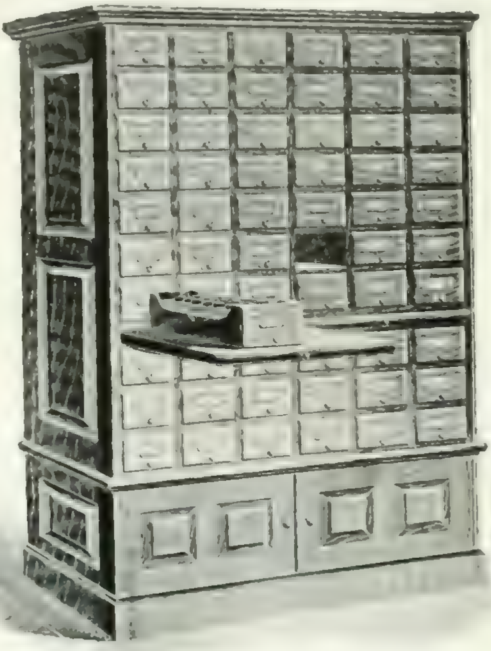

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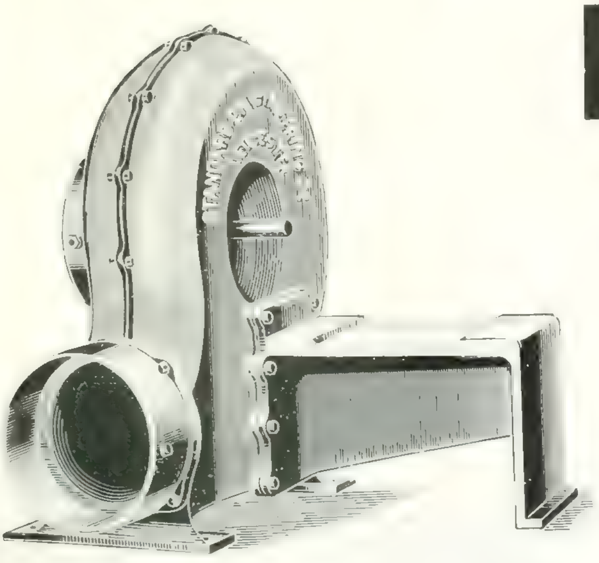

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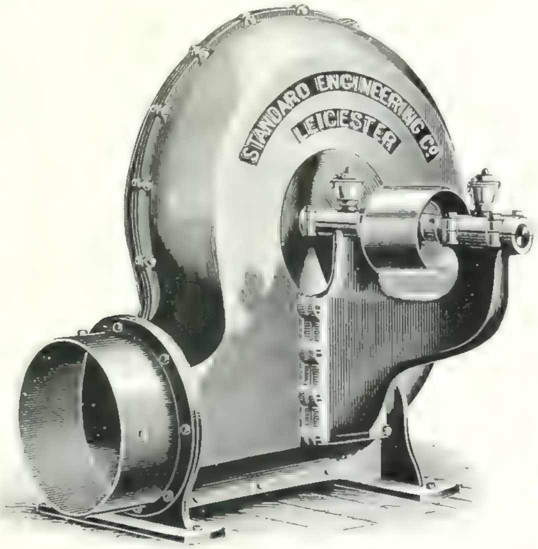

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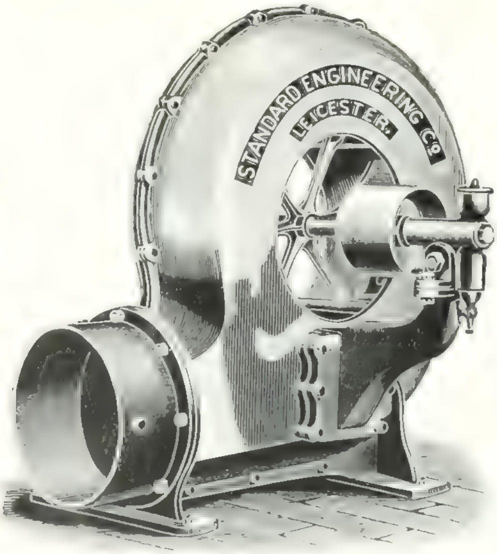

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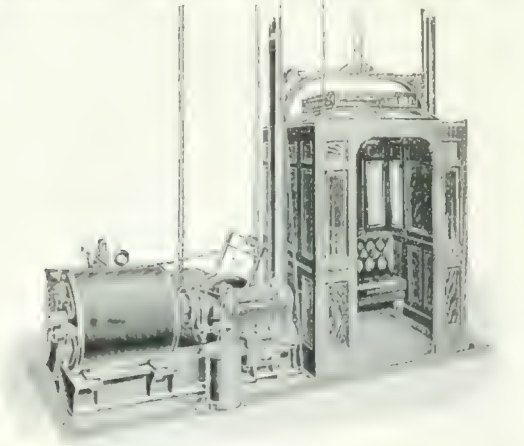

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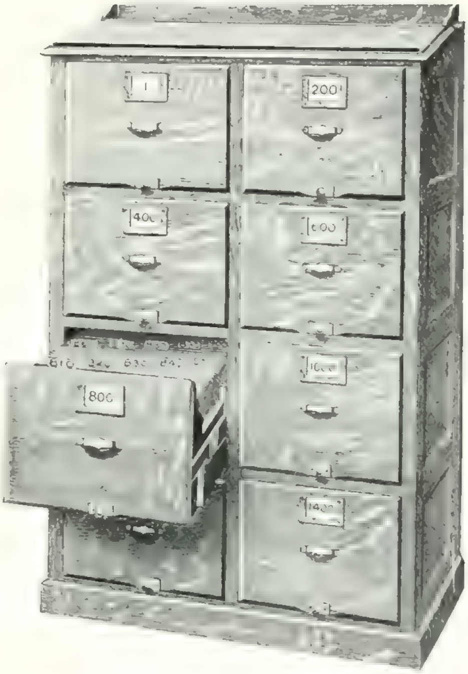

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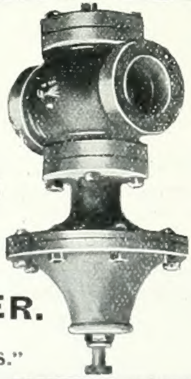

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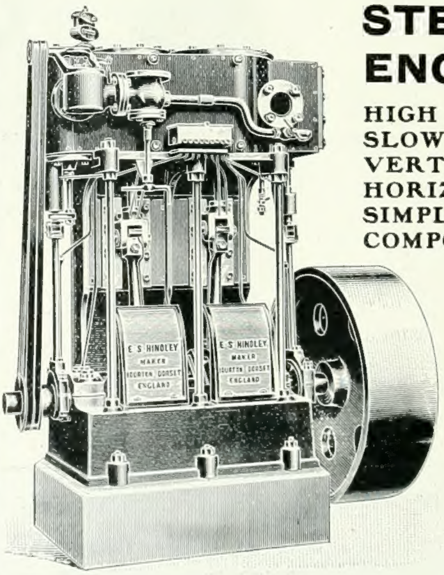
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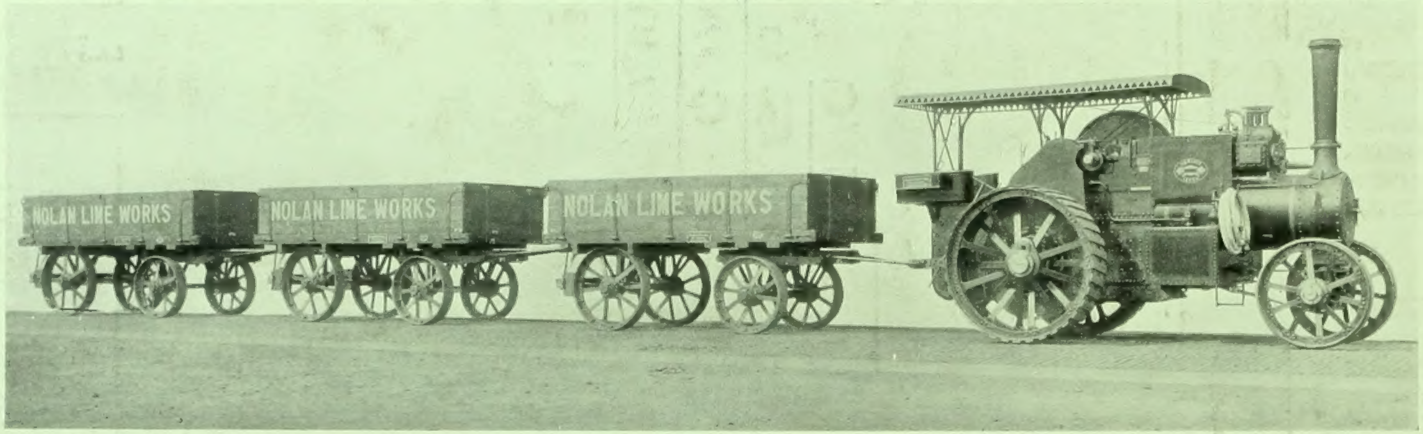

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